PRODUCTION AND VALUE

OF

MINERAL PRODUCTS IN MICHIGAN

FOR

1916 AND PRIOR YEARS

MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

Publication 24.
Geological Series 20.

MINERAL RESOURCES OF MICHIGAN

WITH

STATISTICAL TABLES OF PRODUCTION AND VALUE OF MINERAL PRODUCTS

FOR

1916 AND PRIOR YEARS.

PREPARED UNDER THE DIRECTION OF

R. C. ALLEN

DIRECTOR, MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF GEOLOGICAL AND BIOLOGICAL SURVEY FOR 1916.

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS.
1917

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LETTER OF TRANSMITTAL.

To the Honorable, the Board of Geological and Biological Survey of the State of Michigan:

Gov. Albert E. Sleeper.
Hon. Thomas W. Nadal.
Hon. Fred L. Keeler.

Gentlemen:—Under authority of act number seven, Public Acts of Michigan, Session of 1911, I have the honor to present herewith Publication 24, Geological Series 20, the sixth of a series of annual statements of the production and value of the mineral products of Michigan.

Very respectfully,
R. C. ALLEN,
Director.

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MICHIGAN COPPER INDUSTRY IN 1916.

GENERAL REVIEW.

Michigan copper mines made a record production for the district during 1916. According to the U. S. Geological Survey, the total production of copper in Michigan in 1916 was 273,692,525 pounds, valued at $67,328,361, and that of silver was 716,640 fine ounces, valued at $471,549, a combined value of $67,799,910. This is an increase of $21,078,251, or 45 per cent, over the value of the output in 1915.

The average price of copper per pound for 1916 was $0.246, compared with $0.175 in 1915. The average price of silver for 1916 was $0.658 per fine ounce; for 1915 it was $0.507. The average value per ton of ore treated was $5.34, compared with $3.76 in 1915.

The smelter production, or the output of refined copper, in 1916 was 269,794,531 pounds, which represents an increase of 30,838,121 pounds over the smelter production for 1915.

In 1916 the amount of ore milled was 12,364,114 short tons, which yielded 420,551,291 pounds of concentrates and 268,279,876 pounds of copper. In 1915 the amount milled was 12,334,700 short tons, which yielded 400,178,132 pounds of concentrate and 265,283,378 pounds of copper. The average recovery of refined copper per ton of ore milled in 1916 was 21.7 pounds, compared with 21.5 pounds in 1915.

The year 1916 was one of unusual profits for the Michigan copper companies. A total of $28,840,348.59 was paid in dividends by 15 companies. This amount compares with $15,189,653 paid by 10 companies in 1915. Practically all the producing mines made an increased production, and with the high price received for copper sold, incomes from mining operations were exceptionally large. A number of the developing companies were able to increase operations, and two or three of the companies paid off all debts and ended the year with a balance of assets.

Production was forced to the maximum, and 1916 shows the largest production in the history of the district. Severe winter storms in the early part of the year, and consequent transportation trouble, affected the year's production, especially at the Ahmeek, Allouez, Centennial, LaSalle, Osceola, Mohawk and Wolverine. The principal factor which affected adversely the year's production at all mines was the general scarcity of labor throughout the district. This condition was somewhat improved during the latter part of the year.

Wages during 1916 were the highest in the history of the dis-district. At the Calumet & Hecla and subsidiary companies the 10 per cent premium for the first six months of the year, announced on December 31, 1915, was continued throughout 1916, together with an additional payment of 25 cents per day for each day worked from July 1 to December 31, if the person was in the employ of the company on the latter date. On December 13 notices were posted announcing that the 10 per cent premium would be continued until July 1, 1917, and that from January 1 to July 1, 1917 a 50 cent bonus for each day worked would be paid employees on regular pay days.

At the Quincy wages were advanced seven and one-half per cent March 1, making a total of 15 per cent above normal, and from July 1 an additional bonus of 25 cents per day was given the men. This bonus was advanced to 50 cents per day January 1, 1917. All the companies found it necessary to increase wages from 10 to 20 per cent, and at practically all mines a bonus of 50 cents a shift will be paid beginning January 1, 1917.

Curtailed operations, due to shortage of labor and storms, the advanced cost in materials and supplies, and the increased wages in all departments increased the costs over the year 1915. Extraordinary advance in ocean freight rates and marine and war risk insurance during 1916 also increased the total cost considerably in a few cases.

The most important metallurgical development during the year was the successful inauguration of the ammonia leaching process at the Calumet & Hecla mill. This process was developed from the bottle stage in the laboratory to the present 2,000 ton plant in four years' time, entirely by C. & H. engineers. The present plant has been a commercial and metallurgical success from the beginning.

In connection with the leaching of sands, experiments were conducted by the Calumet & Hecla and by the Michigan College of Mines on the flotation of copper in the slimes, with encouraging results. Minerals Separation machines of 50-ton capacity have been installed at the Calumet & Hecla and White Pine mills.

At the close of the year production was limited only by stamping facilities. Every mill in the district except the Adventure was operating and almost all at full capacity.

At the White Pine Extension, a new company organized in the summer of 1915, the shaft was sunk to a depth of 242 feet, and drifts and crosscuts were driven to explore the copper-bearing Nonesuch beds. A 100-ton experimental mill will probably be built in the summer of 1917.

Southwest of the White Pine Extension, the Porcupine Exploration Company, organized early in the year, carried on a diamond drill exploration along the extension of the Nonesuch formation to the southwest. About 16 holes were drilled, and although some good values were found, the company unfortunately did not consider the showing sufficient to warrant the continuation of the exploration.

Onondaga continued diamond drilling until the summer of 1916, when work was discontinued to await other developments in that section of the district.

In May, 1915, the Algonac Mineral Development Company began a diamond drill exploration of lands between the White Pine Extension and the Nonesuch. A total of 52 drill holes was put down to explore the Nonesuch formation. The results of this work were very satisfactory, and work was discontinued in July, 1916.

In June, 1916, the Cass Copper Company was organized by a group of Copper Country men and purchased 1,980 acres of land in the vicinity of the old Norwich mine. The company holds under option 2,680 additional acres. Diamond drilling was started, and results to date are sufficiently encouraging to warrant the continuation of the exploration.

In the summer of 1916 Mr. R. F. Looney, of Houghton, issued a report on the old Carp Lake mine and offered at private subscription at $3.00 per share a limited number of pre-organization syndicate shares. The property consists of 1,610 acres on Lake Superior about 22 miles west of Ontonagon. The mine is one of the oldest in the Michigan district, and former operations consisted of the exploration of a copper-bearing sandstone. During 1916 the mine was unwatered and some exploration work done.

About the first of November work of pumping out the old Flint Steel mine was started. One of the old shafts will be used to thoroughly explore the Butler lode. The property lies between the Mass and the Michigan mines.

In the spring of the year the Tremont & Devon Mining Company began preparations to clean out the old adits and pits on its property, which adjoins the Victoria to the west. Diamond drill exploration was started to explore the Devon and Forest lodes.

About the middle of October it was reported that supplies were being shipped into Ontonagon county, preparatory to undertaking exploration work at the old Waukulla property. A few weeks later it was announced that W. J. Landon of Winona, Minnesota, owner of the Waukulla property, was planning a thorough geological examination and exploration, based on explorations already conducted. The Waukulla property consists of 480 acres northeast of Lake Gogebic in sections 19 and 20, 49-42, in Ontonagon county. Some exploration was done in the latter seventies.

Another extensive exploration project in Ontonagon county was started the latter part of October, 1916. The E. J. Longyear Company began diamond drilling in the Iron River Silver district north of the White Pine. The work was undertaken for E. F. Anderson of Wausau, Wisconsin, and associates, who hold options on several thousand acres of land in townships 51-41 and 51-42. These lands were systematically drilled to determine whether the sandstone and shale contain copper or silver in sufficient quantity to mine at a profit. Through the courtesy of E. J. Longyear Company we are able to print the following report on the results of these explorations.

RESULTS OF DRILLING IN THE NONESUCH FORMATION BETWEEN THE WHITE PINE MINE AND LAKE SUPERIOR.

BY CLYDE S. LONGYEAR.

Introduction.

This summary covers the exploration work done by E. J. Longyear Company during the winter of 1916-17 in Township 51, ranges 41 and 42, on the Nonesuch Formation between the White Pine Mine and Lake Superior, about 15 miles west of Ontonagon, Michigan.

Drilling was started in the middle of November, 1916, since when 17 holes have been drilled, varying in depth from 38 to 592 feet. All these holes were vertical holes, and all were drilled in the Nonesuch Formation, with the exception of two which encountered the red sandstone foot-wall.

The Nonesuch Formation.

The formations are relatively flat in this district, the dip averaging from 12° to 15° to the East. The Nonesuch Formation belongs to the Upper Keweenawan series, and is overlain by the Freda sandstone, a fine-grained, reddish sandstone. The upper 200 to 300 feet of the Nonesuch consists of banded brown and grey shales, grading occasionally into thin beds of brown or grey grit. Below this member is the upper grit, a coarse-grained grey grit, from 40 to 50 feet in thickness. Underlying this upper grit is 50 to 200 feet of grey shales, mostly very fine-grained. This is underlain by 15 to 30 feet of calcareous banded shale which is fairly coarse and is almost a grit in some places. This banded shale is very easily recognized and serves as a "marker," showing that the mineralized lodes are within 40 to 50 feet.

Below this "marker" is a grey grit known as the Lower Grit, about 20 feet thick, and very similar in appearance to the Upper Grit. The No. 1 shale lies immediately below this, from 5 to 14 feet thick. The mineralization occurs within the bottom 5 or 6 feet of this shale, and extends for a distance of one or two inches into the No. 1 sandstone, or first lode. This sandstone has averaged about three and one-half feet, and has varied in thickness from 1 to 7 feet. The parting shale, immediately below, is from 2 to 11 feet thick, averaging a little less than 8 feet. Below this is the No. 2 sandstone, or second lode, about 3 to 4 feet in thickness. This is underlain by a red sandstone and conglomerate—the foot-wall. At the White Pine Mine and the White Pine Extension, a third lode about 2 to 4 feet thick of grey sandstone and copper has been struck in some of the holes at a depth of from 50 to 100 feet below the second lode. Two attempts were made to strike this lode on these lands, but were not successful.

Mineralization and Faulting.

The mineralization here is confined to the No. 1 shale, and the No. 2, or parting, shale. This, in the main, is the case also at the White Pine Extension Mine, but at the White Pine Mine the main values are found in the No. 1 and No. 2 sandstone. Calcocite was found in these two sandstones in some of the holes drilled here, but no native copper. Some of the holes encountered native silver, but in small quantities. Silver occurred in small amounts in the upper portions of the Nonesuch in the brown shale. The copper for the most part has been fine-grained, appearing between bedding planes of the black shale, and following the small cracks and fissures across the bedding. In some places the copper is in thin flakes from ⅛ to ¼ of an inch across the face. The highest values, however, have come from the finely disseminated copper, rather than the flaky variety.

While there may be some question as to the original source and the manner of deposition of the Nonesuch copper, the drilling here has shown the principal mineralized areas to be in the immediate vicinity of the three northeast and southwest faults.

DETAILS OF OPERATIONS OF THE MINING COMPANIES IN 1916.*

Adventure Consolidated Copper Company.

Preliminary work towards reopening the mine was started in May. All surface plants including the No. 3 rockhouse and No. 3 hoist, were overhauled and put in shape for operation.

No. 3 shaft was found to be filled with water nearly to the surface, and the old timbering in the shaft was so badly decayed that the shaft was partly closed by caving ground from surface to the third level, where it enters solid rock. Unwatering was accomplished as far as the third level by means of a pump and air lift. Below this level the water is being removed by bailing. It was necessary to retimber the shaft entirely down to the third level.

As each level was reached, the drifts were cleaned up and the tracks and air pipes installed as far as the drifts were found to be open. Closed drifts are being cleaned out as rapidly as possible.

Mining operations were started the latter part of November, and shipments of ore to the Winona mill were begun about the middle of December. Production was gradually increased up to the end of the year and by May 1, 1917 should amount to about 300 tons per day.

The lodes which will be developed and mined at the Adventure are the Butler, North Butler, Knowlton and Evergreen. The lodes, where opened, show on the whole a satisfactory copper content.

Ahmeek Mining Company.

Ahmeek made a record production in 1916. All costs were considerably higher than they have been for the past three years, and the yield of refined copper per ton of ore stamped was the lowest of the past nine years.

All four shafts were in operation during the year. At No. 1 shaft all openings and stopes showed ground of average quality, except the workings on the 8th, 10th, 14th and 16th levels south, where the copper occurs in small bunches.

At the No. 2 shaft all drifts and stopes showed copper contents fully up to the average of the mine. In the higher levels the copper is uniformly distributed throughout the lode but from the 16th level down the copper particles, although heavier, are not so uniformly distributed.

The mass copper fissure vein north of No. 2 shaft produced during the year 1,221,845 pounds of copper. All openings on the fissure de-

*For details of production, costs, dividends, assessments, assets and liabilities see statistical tables.

veloped good values and the vein has a promising appearance. On the 10th level, at a point 950 feet west of the Kearsarge lode, the drift intersected a small crossing which seems to have thrown the mass fissure vein out of place, or to have cut it off entirely. The drift was swung to a direction at right angles to the general strike and continued as a crosscut to a point 1,352 feet west of the Kearsarge lode, where the Kearsarge conglomerate was intersected. This crosscut was extended through the conglomerate lode, which is 36 feet wide at this point and carries a small amount of copper in streaks. A drift was driven near the foot side of the lode 127 feet north and 82 feet south but did not develop ground of commercial value. In the south drift, 55 feet from the crosscut, a fissure was encountered which extended 26 feet into the hanging and 60 feet into the foot, and from which 12 tons of mass copper was produced.

All openings at No. 3 shaft showed ground of average quality for that end of the mine, but the stoping has proved that the copper occurs in bunches. The "Fulton fissure vein" crosses No. 3 shaft just below the 17th level. On the 15th level south this vein was followed 95 feet to the east and 136 feet to the west. A number of fair sized masses of copper were obtained in the fissure; work at this point has been discontinued.

At the No. 4 shaft all openings for the year showed ground of average quality for that end of the mine. During 1917 a vigorous campaign of opening will be conducted.

At the stamp-mill No. 7 stamp went into commission July 1 and No. 8 will be ready in February, 1917. Some La Salle ore was stamped when sufficient Ahmeek ore was not available to keep stamps to full capacity.

For premiums and bonuses see Calumet & Hecla Mining Co.

Algomah Mining Company.

The operations of the Algomah during 1916 consisted of sinking the shaft 80 feet to a total depth of 558 feet. The cost of sinking was $47.59 per foot.

Difficulty in obtaining delivery of a new boiler and very unsatisfactory labor conditions were responsible for the small amount of development work done.

Shaft sinking will be resumed as soon as labor conditions permit.

Algonac Mineral Development Company.

This company carried on diamond drill exploration work on lands between the White Pine Extension and the Nonesuch. The work was begun in May, 1915 and discontinued in July, 1916. See map of Ontonagon county.

A total of 52 drill holes was put down along the strike to explore the Nonesuch formation which is mineralized to the west at the White Pine Extension and to the east at the Nonesuch. The line of holes drilled extends from the S. W. ¼ of the N. W. ¼ of section 8 in a general northeasterly direction through the S. E. ¼ of the S. E. ¼ of section 5 to the center of the east half of section 4. Another line of holes extends from the N. W. corner of section 9 east along the north lines of sections 9, 10 and 11.

The results of the drilling indicate a fold in the formation and a fault running through about the west half of section 10.

The beds were found to be fairly well mineralized, and several cores were exceedingly rich in native copper.

Allouez Mining Company.

Allouez's production for 1916 showed an increase of 175,831 pounds over that of 1915, the previous record production of the company. Costs were higher than in 1915 but lower than costs in the four years preceding 1915.

Copper returns from the stopes tributary to No. 1 shaft were somewhat below average, this being especially true as stoping operations on the north side gained toward the shaft.

At the No. 2 shaft stoping operations yielded better than average copper returns, with especially good ground stoped toward the extreme north on the 14th to 17th levels inclusive. The mine to the north of No. 2 shaft will be equipped with electric locomotives on a 125-volt trolley system.

For premiums and bonuses see Calumet & Hecla Mining Co.

Baltic Mining Company.

Baltic's operations during 1916 showed an increase in production over that of 1915. The yield of copper per ton of ore stamped was 33.64 pounds.

No. 2 shaft was the chief producer, and the ground opened during the year was fair. At the bottom of shafts Nos. 3 and 4 developments have shown some improvement. The west lode was worked throughout the year from all the shafts, although almost all the production from this lode came from Nos. 4 and 5 shafts.

Equipment will be set up in the addition to the mill building in the early part of 1917, and when this is finished, complete regrinding of all coarse tailings will be possible.

Calumet & Hecla Mining Company.

During the year 1916 the C. & H. produced 76,762,240 pounds of refined copper, of which amount 71,349,591 pounds was produced by the mine, and 5,412,649 pounds was recovered by the reclamation plant at Torch Lake. The total cost per pound of copper produced from the mine was 11.63 cents, and the price received for copper sold varied from 22½ cents to 35½ cents per pound.

On the conglomerate lode the work of removing shaft pillars and cleaning up arches and the backs of old stopes was continued throughout the year, and about 78 drills were employed in this work. A total of 476,310 tons was secured from these operations.

Openings on the Osceola lode continued to show about the same grade of ore. The production from foot-wall stopes was about 33½ per cent of the total production from this branch. Shaft openings are far in advance of drifts.

No work was done on the Kearsarge lode during 1916. No work was done at the Manitou-Frontenac and St. Louis branches during the year.

At the stamp-mills both the No. 1 and the No. 2 regrinding plants operated satisfactorily throughout the year. The remodeling of No. 1 plant should be finished during 1917. The comparative results for 1916 for the two plants on mill tailings are as follows:

	No. 1	No. 2	Total
Tons coarse tailing crushed	364,581	182,705	547,286
Pounds per ton in material treated	13.98	13.98	13.98
Pounds copper saved per ton	3.79	4.98	4.18
Pounds copper produced	1,380,344	909,453	2,289,797
Cost per pound, excluding smelting and selling	6.32c	4.30c	5.51c

The leaching plant was started on a limited scale in July, but owing to slow deliveries of material, was only half in commission at the end of the year. The cost, exclusive of smelting and selling expense, was under six cents per pound.

The whole plant of 2,000 tons daily capacity will be in operation before the spring of 1917 and will be able to handle only tailings from No. 2 regrinding plant. Results thus far have been so satisfactory that an addition of 2,000 tons capacity will be built to take care of the tailings from the stamp-mill.

The reclamation plant ran continuously throughout the year. The results of this plant, including leaching are as follows:

	Year 1916	Since starting
Tons tailings treated	545,727	727,459
Pounds per ton in material treated	21.06	21.24
Pounds copper saved per ton	9.92	9.62
Pounds copper produced	5,412,649	6,995,451
Cost per pound, excluding smelting and selling	4.58c	4.39c

The new furnace at the smelter went into commission November 1.

On December 23, 1916 the Calumet & Hecla sold its 11,207 shares of Seneca Mining Company for $60 a share, receiving $672,420. In making this sale, it was stipulated that the other shareholders should receive an offer of $60 a share for their shares, provided these were presented within a reasonable time. The Calumet & Hecla, therefore, has no further interest in the Seneca Mining Company.

On July 15, 1916 the fiftieth anniversary of the opening of the mine was celebrated, by a general holiday. Long service medals were given to 1,371 employees.

The ten per cent premium for the first six months of the year, announced December 31, 1915, was continued throughout 1916, together with an additional payment of 25 cents per day for each day worked from July 1 to December 31, if the person was in the employ of the company on the latter date; this payment to be made on the first pay day in January, 1917. On December 13 notices were posted announcing that the ten per cent premium would be continued until July 1, 1917, and that from January 1 to July 1, 1917, a 50 cent bonus for each day worked would be paid employees on regular pay days.

The above statement of premiums and bonuses also applies to the following Calumet & Hecla subsidiaries: Ahmeek, Allouez, Centennial, Isle Royale, La Salle, Osceola, Superior and White Pine.

Carp Lake Mine.

In the summer of 1916 interest was revived in the old Carp Lake mine, located about 22 miles west of Ontonagon near Lake Superior. The property consists of 1,610 acres and was formerly worked in 1863.

About the middle of June, 1916, Mr. R. F. Looney, of Houghton, who holds the controlling interest in the property, issued a report on the mine by Mr. Jerry Rourke, of Hancock, and offered at private subscription at $3.00 per share a limited number of pre-organization syndicate shares.

According to the report of Mr. Rourke, the ground leaving Lake Superior rises gradually for a half mile or more, where it becomes steeper and reaches the backbone of the Porcupine Mountains at an elevation of 1,100 feet above the lake and at a distance of one mile from the shore line. To within 100 feet of the top of the mountain, the formation is sandstone, which is capped by a flow of trap rock. The upper 30 feet of sandstone just under the trap rock is impregnated with native copper, forming the vein, which on account of the physical features, may be easily traced throughout the property. The sandstone, trap and the vein, which follows the stratification of the sandstone, all strike east and west and dip north toward and under Lake Superior. All of the 30 feet of sandstone is not mineralized, the copper occurring principally in the upper six feet and the lower ten feet, with 15 feet or so of barren sandstone between. The copper occurs in lenses up to several inches in thickness and as sheets along the bedding planes. The mineralization is uniform for a distance of a mile along the vein, as exposed in the old workings and in a number of cuts and shallow shafts along the outcrop.

Exploration work was carried on at the property during the summer months. Three old shafts were unwatered and cleaned out, and the old workings examined. It is reported that all shafts opened show the upper six foot strip of rich copper and that a crosscut in No. 9 shaft determined the lower mineralized strip to be as rich as where opened on the face of the cliff, at which point Mr. Rourke states the amount of copper to be remarkable.

Cass Copper Company.

The Cass Copper Company was organized in June, 1916 under the laws of Michigan, with a capital of 150,000 shares, par value $25. The men interested in the syndicate are well known mining and business men of the Copper Country and associates from Chicago, Minneapolis and southern Michigan.

The company has purchased 1,980 acres of land in Ontonagon county in the vicinity of the old Norwich mine. (See map of Ontonagon county). Besides the 1,980 acres the company holds under option about 2,600 acres lying to the east and north of the Norwich.

A geological survey of the property was made by A. H. Meuche, and diamond drilling was started to explore the Forest lode. Five holes have been drilled in section 6, two holes in the N. W. ¼ of section 12 and one hole in the S. W. ¼ of section 1.

Although no copper of commercial value has been found to date, the results of the work are very encouraging and the exploration will be continued.

Centennial Copper Mining Company.

Severe winter storms in the early part of the year and consequent transportation trouble, together with the general scarcity of labor affected Centennial's production during 1916. The total production, however, showed an increase over that of 1915.

Openings to the north of No. 2 shaft disclosed some promising stretches of ground. Stopes for the year yielded average copper returns.

The Centennial has granted the Wolverine a license to mine a triangular piece of ground about one acre in area, in the N. E. 1/4 of the N. E. 1/4 of section 12, Town 56, Range 33 in exchange for similar rights on an equal amount of land in the N. W. 1/4 of the N. W. 1/4 of section 7, Town 56, Range 32.

For premiums and bonuses see Calumet & Hecla Mining Company.

Champion Copper Company.

Champion made another record production during 1916. At a total cost per pound of 7.80 cents and a yield of 35.87 pounds of refined copper per ton of ore stamped, the mine produced 33,601,136 pounds of refined copper. Net profits were $5,870,606.26.

Openings made during the year developed good ground. The filling of old stopes is about completed, and less sand will probably be required for fill in the future. Towards the end of the year shaft sinking was resumed, no work of this kind having been done for nearly three years. The mill is now equipped for complete regrinding.

Cherokee Copper Company.

Exploration work was continued at the Cherokee with very encouraging results.

In April a site for the shaft was cleared, foundations laid, machinery installed and in July shaft sinking was started.

Cherokee is exploring an uncorrelated, epidote amygdaloid, from 30 to 45 feet in width, striking in general N. 45° E. and dipping about 62°. The amygdaloid has been opened on surface for about 1,200 feet along the strike, and good mineralization has been found in all surface openings.

At the end of the year the shaft was down about 250 feet. At a depth of 110 feet drifts were driven northeast and southwest in order to determine the strike and character of the foot-wall. At the end of the east drift a crosscut was made through the lode and into the hanging-wall the lode showing a width of 26 feet. The openings at the 110 foot level total about 120 feet. At a depth of 220 feet No. 2 plat was cut, and drifting is now under way.

The shaft throughout its total depth of 250 feet, with the exception of only 30 feet, has shown persistent mineralization of an encouraging character. The 30 feet showed slight mineralization compared with the other openings.

Copper is found in heavy form in a very irregular banded structure, the banding conforming more or less to the general strike of the lode and in the upper part of the shaft shows a decided tendency to follow rather closely the foot-wall. This, however, is becoming less pronounced with depth, and at the 200 foot level and bottom of shaft heavy copper has been found 12 feet from the foot-wall. Besides the heavy banded form of copper, shot copper and very fine granular particles appear at irregular intervals in the lode.

An assessment will probably be called in the spring, and operations during 1917 will be watched with interest.

Contact Copper Company.

Operations of the Contact during 1916 were restricted to a continuation of the diamond drill exploration of the beds crossing the southeastern portion of section 11, 52-36. The object of the work was the further investigation of the No. 8 Wyandot amygdaloid lode.

The No. 8 amygdaloid was cut in both of the holes drilled and was found to be generally soft and carrying a very small amount of exceedingly fine copper. The dip of the beds was found to be about 66°, which agrees with the dip of the formations farther west on the property at the horizon of the Winona lode.

The four holes drilled in this part of the property have disclosed a formation of about 35 feet average thickness, showing a uniformly favorable character of rock with a small degree of mineralization. Supt. G. S. Goodale considers the results encouraging and warranting further exploration of the No. 8 amygdaloid.

In order to protect the company's cash resources, further work on the property was suspended June 29, pending results at the Wyandot to the south. Diamond drill investigation of the same horizon is also being made by the Copper Range on lands to the north. The directors thought it wise to await further developments at both these points before resuming active operations at Contact.

Copper Range Company.

Operations of the Copper Range during 1916 showed a net income of $6,078,189.65. This is equivalent to net earnings of $15.40 per share. $10 per share was paid in dividends, and the balance added to working capital.

The total production of the Copper Range mines, Baltic, Trimountain and one-half of Champion, was 37,946,930 pounds, an increase over the previous year of 911,288 pounds. The average yield of copper per ton of ore stamped was 33.07 pounds. Each of the three mines showed an increase in output for the year.

Considerable development work was done, and new stoping ground was developed equal in tonnage to that extracted during the year. The Copper Range secured an option from the St. Mary's Mineral Land Company on about 3,500 acres of land south of the Copper Range mines. A preliminary exploration is now being made of this land by diamond drilling.

Copper Range purchased from the South Range Mining Company for $50,000 about 5,000 acres of scattered lands in Houghton and Ontonagon counties.

The Trimountain Mining Company will probably be dissolved in 1917.

Flint Steel.

Work of pumping out the old Flint Steel mine for the purpose of examination of the workings was started November 3d. This work was completed December 16th. Mr. Samuel Brady of the Michigan, who was in charge of the work, states that the work thus far has resulted in no activity at the property, though it is hoped that it may ultimately do so.

The property consists of the east ½ of the N. E. ¼ and the S. E. ¼ of section 11 and all of section 12, between the Michigan and the Mass.

Nipissing has taken an option on the property, and the unwatering was for the purpose of a thorough exploration. Flint Steel was last worked in 1875 on a fissure vein.

Franklin Mining Company.

Franklin had a very successful year in 1916. Production was considerably increased, and new development work opened up very good ground. The future of the Franklin is very promising. At the end of the year all notes payable, amounting to $155,000 had been paid from earnings, and the company now has no indebtedness of any kind outside of current expenses.

Drifts in the Allouez conglomerate tributary to No. 1 shaft were extended on levels 21 and 26 to 36 inclusive, and stoping was begun in this newly developed section of the mine. The ground developed to the north is below average grade with some well mineralized areas of small extent.

To the south nine drifts were carried to the dividing line between No. 1 and No. 2 shafts. These drifts developed average stoping ground throughout practically their entire lengths, with the best values showing in the ends towards No. 2 shaft. Two other drifts, the 27th and 32nd, were extended beyond the downward extension of the center line of No. 2 shaft to test the ground through which this shaft is to be sunk. These drifts disclosed a greater width of lode, carrying more copper per ton, than is to be seen in the section of the mine now being worked.

Early in the spring work was started to reopen No. 2 conglomerate shaft which had caved to surface. The work of cleaning out and retimbering this shaft is being pushed as rapidly as possible, as it is very desirable to resume sinking in order to develop and mine the good ground opened by the south drifts from No. 1 shaft.

The long crosscut on the 32nd level was driven through the Kearsarge lode and stopped on the foot-wall side of the Wolverine sandstone, 4,542 feet from the Pewabic amygdaloid. Copper in sufficient quantity to warrant further exploration was found on the footwall side of the Kearsarge amygdaloid, but owing to shortage of men, no drifting was done.

It has been the custom at the Franklin, because of a very soft hanging-wall, to leave the uppor portion of the lode, amounting to one-third to one-half of its width, as a beam to support the hanging of trap. In the latter part of the year a rope haulage was installed on the 29th level south, and a system of stoping was begun with a view of removing practically the entire width of lode including the floor pillar of the level above and allowing the trap hanging to cave behind the men. Similar systems were installed on two other levels, and the results have been exceedingly favorable. Others are being put in as rapidly as possible. This new system makes possible a recovery of a greater tonnage from a given area of lode, a reduction in the cost of stoping, an increased production and a marked decrease in tramming cost per ton.

Every effort was made to increase production, and at the end of the year the ore sent to the mill showed an increase in tonnage of more than 40 per cent over the average for the first six months. Three of the four units at the mill are now stamping Franklin ore, and when mining begins in No. 2 shaft, the fourth, which is now doing custom work, will also be supplied with ore.

Hancock Consolidated Mining Company.

Although operations at the Hancock were carried on under a great many difficulties, the results for the year were fairly satisfactory. Practically all dead work in the nature of driving long crosscuts and opening up work for chutes between levels has been completed. The mine at the close of the year was in far better physical condition than at any time in the past, and production should be increased 100 per cent in 1917.

Development work in the lower levels exposed average ground. The copper is better distributed than in the upper workings, and considerable mass copper is being encountered. Crosscuts were driven to the West branch, which is 115 feet west of the main lode, at two of the lower levels. The average width of this lode is about four feet. It is bunchy but carries good grade ore and considerable mass copper.

The development work was confined to blocking out ground for mining in the lower workings tributary to No. 2 shaft and to extending levels south from Quincy No. 7 shaft into Hancock territory from the 66th to 71st levels. The ground mined south of No. 7 shaft was well mineralized.

Electric haulage is being installed on the lower levels of No. 2 and No. 7 shafts and when completed will make possible the handling of a greater tonnage at a far lower cost.

Houghton Copper Company.

Houghton Copper produced 204,274 pounds of refined copper during 1916, at a yield per ton of ore stamped of 10.55 pounds.

Stoping was carried on both north and south of the main shaft on the 6th level, where the shaft is now bottomed. At the 450 foot level a crosscut was driven through the Superior lode which showed a width of 28 feet. Drifting was done both north and south, and, while the lode showed some copper, it was not encouraging.

The winze was sunk 113 feet below the 1,020 foot level, and a crosscut was driven through the Superior lode which showed a width of 40 feet with good ore on both foot and hanging sides. Drifts to north and south on the Superior lode at this level opened fair ground. The lode is now being cut out on the north side of the winze and hoisted as ore. President Paine states that the main lode on the 12th level looked to be as good as, or better than any other place in the mine, but not good enough to warrant the sinking of the main shaft from the 6th to the 12th level.

The crosscut from the winze was extended from the Superior lode to the west and driven through the West lode, which showed a width of 15 feet. The distance from the hanging of the Superior lode to the foot of the West lode is 123 feet. Drifts to north and south on the West lode encountered some nice heavy bunches of copper, but only a very small proportion of the ground opened showed any copper.

Indiana Mining Company.

Search for the body of felsite from which the No. 2 drill core was obtained was continued at the Indiana during 1916. Crosscuts to the east and drifts north and south on the 1,150 and 1,400 foot levels were made in an endeavor to locate this much desired deposit.

Felsite was found on both levels, and the contact between it and the trap was followed for several hundred feet in different directions. Copper was found at a number of places in the felsite near the contact, but not in commercial quantities. No. 2 drill hole was not found, but No. 9 hole was cut by one of the openings at the 1,400 foot level, at about 100 feet northeast of its theoretical position.

Concerning this extended exploration work in search of the rich deposit, General Manager Edwards states as follows: "All the exploration work done at the 600, 1,150 and 1,400 foot levels, taken in connection with the large amount of diamond drilling in addition to No. 2 hole, leads to the conclusion that the deposit from which No. 2 drill obtained the rich core cannot be of very great size or have any regular trend, otherwise it would have been encountered at some other point in the work. This cannot be considered as proved as yet, and it is not the intention to convey the idea that all hope of locating a valuable deposit on this part of the property has been abandoned, but, after serious consideration, the directors decided that the prospects of developing a mine within a reasonable time were brighter in the horizon of the South Lake amygdaloid lodes."

Late in the year No. 2 shaft was started in the S. W. ¼ of section 21, and by the end of the year had reached a depth of 124 feet. The shaft will be sunk on the dip to 300 feet, at which depth the group of South Lake lodes will be explored by crosscutting and drifting.

Isle Royale Copper Company.

Isle Royale made a profit of $1,396,655.01 in 1916. Three dividends, amounting to $750,000, were declared during the year. A notable increase in production was made, and ground developed during the year is good.

The No. 1 shaft was unwatered and timbered to the bottom, 79 feet below the 16th level. All openings from this shaft, with the exception of 70 feet of crosscutting, were on the West lode, and about 38 per cent developed ground of apparent commercial value. About eight per cent of the total tonnage shipped to the mill came from this end of the mine.

Sinking was carried on at No. 2 shaft. The inclination of this shaft is being flattened in order to reach the West lode, in which future sinking will be done. About 65 per cent of the openings from this shaft to the south in the Isle Royale lode disclosed ground of average copper content. In the drifts in the West lode north of the shaft about one-half of the ground opened contained copper.

At the No. 4 shaft about 75 per cent of all ground opened shows copper values fully up to the average of the mine. On the 6th level north at a point 200 feet from the shaft, a crosscut has been started into the foot to explore an amygdaloid which lies about 350 feet east of the Isle Royale lode.

At the No. 5 shaft about 73 per cent of the ground opened shows copper.

At the No. 6 shaft good values are exposed at the bottom of the shaft, which is now 58 feet below the 17th level in the lode. About two-thirds of the ground opened during the year shows copper.

Sinking was carried on at No. 7 shaft. At the end of the year the bottom was in the lode 59 feet below the 7th level, where good copper values are exposed. Drifts tributary to this shaft developed fair ground.

At the various shafts considerable construction work was done. Several improvements were made at the mill, which ran with great efficiency all the year.

For premiums and bonuses see Calumet & Hecla Mining Company.

Keweenaw Copper Company.

All work during 1916 was conducted on the property of the Phoenix Consolidated Copper Company.

Sinking of No. 1 shaft was continued, and the total depth of shaft is 1,616 feet. Drifting during the year was in general towards the foot-wall side of the Ashbed lode. A total of 4,899 feet of drifting was done to the east and to the west, and practically all openings developed fair to good copper ground.

The "Old Phoenix" fissure was explored from a point where it was cut on the 7th level east by a crosscut northward to the hanging wall of the Ashbed lode. No copper was found in this fissure except where it cuts the lode near the foot-wall, at which point good values are exposed. This fissure will be explored to the south as soon as more men are available.

The Ashbed lode was explored by diamond drills on five different levels. A total of 32 holes was drilled, and the results show that where copper was not found in the drifts, the drill cores generally show copper either in the hanging or foot-wall.

In the latter part of the year preparations were made to commence stoping and milling. A rockhouse and railroad trestle were constructed, and track laid, connecting the mine with the stamp-mill. The mill was overhauled, and stamping was commenced on October 13th.

Four Overstrom and three Wilfley tables constitute the concentrating equipment of the mill. It was found that the Overstrom tables did not make a satisfactory recovery, and they will be replaced by four Wilfley tables. The total copper content per ton of ore stamped was 15.98 pounds, but there was a mill loss in copper per ton stamped of 6.02 pounds. As soon as possible arrangements will be made with the Minerals Separation North American Corporation to begin tests with its process for the further saving of copper values in the finer grades of materials treated in the mill.

Lake Copper Company.

Operations at the Lake during the year ending April 30, 1917, resulted in a total excess of receipts over expenditures of $108,-194.94. The production of refined copper for the 12 months ending April 30, 1917 was less than that for the nine months ending April 30, 1916. The recovery of refined copper per ton of ore stamped dropped from 26.42 to 21.14 pounds.

Considerable attention was devoted to the Knowlton and Butler lodes in the north portion of the property. The old Knowlton shaft was used to explore these lodes and the exploration gave encouraging results. Production will begin from stopes on the Knowlton lode in the summer of 1917. At the same time more extensive developments on the Butler lode will be pushed.

At the Lake shaft the work during the fiscal year consisted chiefly of opening and stoping the levels already developed. Considerable stoping ground was opened up in the upper levels.

New work was done on the seventh level south, about 200 feet south of any stopes in that portion of the mine. This work showed fairly good ground. On the 11th level, the lowest level of the mine, the east lode was drifted on for about 400 feet. The lode showed fairly good mineralization, but it was so narrow that work on it was stopped.

The Butler-Knowlton series of veins on the north side of the property was explored by means of the Knowlton shaft, which was down 600 feet. The shaft was unwatered, and hoist and compressor installed. A crosscut was driven from the Knowlton lode 550 feet to the Butler lode on the sixth level east. This crosscut was continued 100 feet further to the Ogima lode where 30 feet of drifting was done without promising results.

Drifts were driven east and west from the crosscut on the Butler lode and they have shown good results. The lode is very well mineralized and averages about 15 feet in width. The Knowlton lode is being worked on the third, fourth and sixth levels, and at all of these points is carrying good values.

Lake Milling, Smelting and Refining Company.

At the No. 1 mill, Point Mills, a concrete reservoir and a steel tower were built to afford water storage for protection against fire. These are fed by an electric pump located on a small creek east of the mill.

At the No. 2 mill, Hubbell, owing to the general shortage of labor and to slow deliveries of material, work progressed slowly on the two new stamp units. It will probably be early summer, 1917, before either of the units will be in operation.

La Salle Copper Company.

Besides the general scarcity of labor and transportation trouble, which affected production, operations at La Salle were also retarded by insufficient stamping facilities. The Franklin mill continued to stamp La Salle ore but in amounts gradually decreasing, and since October 1 the Ahmeek mill has been handling a portion of La Salle's product.

At the No. 1 shaft mining operations consisted of stoping on four levels and drifting on one other level. The stopes in general were rather lean, with patches of fair ground occurring irregularly. The water in this shaft was lowered from the 15th to the 17th level.

At the No. 2 shaft sinking was resumed and carried below the 20th level. Where the lode was opened near the hanging, fair copper contents were found. A small amount of stoping was done on two levels north in fair ground. Openings were extended on alternate levels and disclosed fair stoping ground on the north side of the shaft. On the south side the openings indicate stretches of poor and fair stoping ground, the lower levels being the best.

By an arrangement with the Osceola Cons. Mining Co., the 42d level south of No. 6 shaft, Osceola mine, was extended into La Salle territory for exploratory purposes. At the end of the year this opening had reached a point 692 feet south of the Osceola boundary, with a very encouraging showing of copper throughout this distance. This drift will be extended as much farther as seems advisable, and the 45th level drift, which is now near the La Salle line, will also be extended in the same way.

For premiums and bonuses see Calumet & Hecla Mining Company.

Mass Consolidated Mining Company.

Credit is due to Supt. E. W. Walker for the very satisfactory results obtained during 1916 and for the present condition of the mine. Production was increased, and the yield of copper per ton of ore stamped was 16.51 pounds, compared with 14.35 in 1915. The total operating profit for the year was $525,083.98; two dividends of $1.00 each were paid, amounting to $194,634, and $235,893.95 was added to balance of assets.

Cost of labor was 18 per cent higher than in 1915, and all supplies showed an equivalent increase, yet the actual cost of producing copper increased only about six per cent over the cost in 1915.

The results obtained underground were very satisfactory, as the work done on the 5th level at "C" shaft shows that the Evergreen lode is well mineralized as far west as "C" shaft in entirely new territory, and there was obtained from the Butler lode an increased production of ore per unit of lode area.

Development work done during the year added to the reserves a tonnage in excess of the extraction. In addition to the reserves added by regular development work, there are now available all the workings of the old Evergreen mine which has been unwatered. Connections are now being made from the present workings to the old mine, and inspection of the old workings shows a large amount of favorable stoping ground which will soon be available for production.

Numerous additions and improvements were made to the equipment which will not only make possible an increase in production but will permit the work to be done more economically and without the delays experienced due to the limited power plant.

Mayflower Mining Company.

Diamond drill exploration was continued at the Mayflower during 1916.

At the close of 1915 hole No. 41 had reached a depth of 2,569 feet. The continuation of this hole, however, disclosed a bed of soft, sandy material which made further drilling impossible. The hole was abandoned in February at a depth of 2,635 feet, without disclosing the position or character of the Mayflower lode.

It was considered advisable to make another effort to locate the lode at depth, and No. 42 hole was started in February, about 600 feet along the strike northeast of No. 41. Hole No. 42, to a depth of about 2,100 feet, where it cut the St. Louis conglomerate, indicated a uniformly favorable condition of the strata and agreed in general with the results obtained in No. 41. Below the St. Louis conglomerate and to a depth of 2,653 feet, several zones of crushed and decomposed ground were encountered which made the operation of the drill difficult. The small portion of core obtained at this depth showed a condition apparently similar to that disclosed at the bottom of No. 41. With further progress practically impossible, drilling operations in this hole were abandoned on October 10th at a depth of 2,697 feet.

The earlier drilling on the property, however, had developed sufficient promise that the directors of the company thought it advisable to make further exploration by means of a shaft, provided an arrangement could be made with the adjoining Old Colony Copper Company for a division of the expense. The only satisfactory way that could be found for dividing the expense was by a consolidation of the two companies. The new consolidated company will probably be formed before the spring of 1917.

Michigan Copper Mining Company.

Operations at the Michigan during 1916 were carried on as planned when work was resumed in July, 1915. The results of this work seem to justify the belief of Supt. Brady that a new and prosperous mine will soon be producing on the Michigan property.

In the spring of the year sinking in "E" shaft on the Butler lode was completed to a total depth from surface of 630 feet. In the progress of the work of shaft sinking, little or no copper was found until a point about 50 feet above the 6th level was reached, when it appeared in very considerable quantities upon the hanging side of the shaft. This mineralization was followed by the shaft in the work of development to a point about 15 feet below the 6th level, at which point it was cut off by a flat slip, dipping from the east side of the shaft.

At the 6th level drifts were driven to west and east of shaft, and some very good ground opened up. By means of a raise over the top of the fault, a more or less continuous run of good ground, of undetermined width, was traced through to the 5th level above, at which point the ground is still of undetermined width and of excellent character.

About the first of June a main crosscut was started south 20° east on the 6th level from a point about 25 feet east of the shaft line. This crosscut was driven for a total distance of 526 feet, or to a point about 50 feet beyond the foot-wall side of the Evergreen lode. The results obtained by this work are interesting and very satisfactory. The crosscut will be continued to No. 8 conglomerate.

In driving this crosscut several belts of mineralization were crossed. From one of these about one-half ton of mass and a number of tons of excellent ore were obtained. Two or three different zones of shearing were encountered, all of which were more or less mineralized. One of these which is well mineralized with mass and fine copper is believed to be identical with the fault line which was found to have cut off the rich ground on the hanging side of the Butler lode in the shaft.

The Ogima lode was reached by the crosscut at a distance of 180 feet. Separated from the main amygdaloid part of this bed by a trap parting about five feet in thickness, is another strong zone of shearing. This zone conforms in strike and dip with the Ogima lode and, where intersected by the crosscut, was found to carry copper in very satisfactory quantities.

A drift was driven about 250 feet west on the Ogima lode, and a crosscut made into the foot for about 75 feet. The drift for the first 100 feet showed fine shotty copper in commercial quantities, through a width of five to eight feet. At 100 feet a cross fissure, striking about N. 45° E., was encountered, which was fairly well charged with sheety masses about one inch in thickness. To the west of this fissure the copper contents of the lode appeared to diminish for about 80 feet. Beyond this point sheety masses, associated with some excellent ore, appeared upon the hanging side of the drift, while the amygdaloidal character of the main Ogima lode appeared to diminish. Further drifting to the west indicated warping of the Ogima hanging to the south and the presence of a bed of trap, striking north and south, which has caused the faulting of the Ogima lode. A crosscut following the east side of this trap was driven for 75 feet from the hanging of the drift. Ragged masses and fine copper were found in this direction, and the face of the crosscut was still in copper-bearing ground when work was suspended.

The main crosscut passed through the hanging of the Evergreen lode 175 feet from the Ogima lode. The Evergreen lode was found to have a width of 48 feet and a dip of 43° to the northwest, with a strike of N. 70° E. Drifting on this lode was carried about 180 feet to the west through somewhat bunchy but fairly well mineralized ground. The ground opened up by this drift is characterized by a general uniform run of fine copper upon the foot side which, upon meeting cross slips, seems to be carried well into the hanging. One point opened by widening of the drift showed mineralized ground 16 feet wide, with copper still in the hanging.

On the 5th level drifting was done to east and west of the shaft. Promising ground was found to the east. A crosscut was driven 150 feet north on this level for the purpose of intersecting another parallel line of shearing which outcrops a little over 100 feet to the north of the shaft. A drill hole in the face of the crosscut found copper ground along the extension of the crosscut.

Various improvements were made at the mill and this work is being pushed as rapidly as possible.

There was shipped during the year a little over 90,000 pounds of mass copper, taken from openings on the Butler, Ogima and Evergreen lodes during development work. There is in stock at the mine about 4,200 tons of ore.

Mohawk Mining Company.

New openings made during 1916 in ground tributary to No. 1 shaft showed less mineralization than openings made during 1915. This was due largely to local disturbances found north of the shaft which necessitated considerable drifting in barren ground.

Exploratory crosscuts were driven to the east and west on the 21st level at a point 670 feet south of No. 2 shaft. The crosscut through the hanging to the west had reached a distance of 641 feet at the end of the year and the crosscut in the foot to the east a distance of 579 feet. Several amygdaloids were intersected, but none warranted further investigation at the present time. The Wolverine sandstone was encountered in the east crosscut at 325 to 351 feet from the foot-wall of the Kearsarge lode.

At the No. 2 shaft drifting on the 22nd level north opened poor ground, and drifting on the same level to the south fair ground. No. 2 will possibly be eliminated during 1917.

New openings in Nos. 4, 5 and 6 shafts show the lode to be of excellent quality. North of No. 6 shaft a fissure, varying in width from eight to 15 feet, has been traced from the 7th to the 11th levels. Indications of copper were found at each level, but the extent of the mineralization into the foot and hanging of the Kearsarge lode has not yet been determined.

Extensive repairs were made in No. 4 shaft, and several improvements installed in No. 6. Little new work was done at the stamp-mill.

Naumkeag Copper Company.

All the exploration work for 1916 was confined to the workings from No. 4 adit at the north end of the property.

Drift No. 2 south was driven on the old Pewabic lode to a point about 2,000 feet southwest of the adit and is the most southerly opening on the property. No copper was found in this portion of the lode.

A crosscut to the east from No. 2 drift was driven to a point about 1,150 feet, but only one of the beds disclosed showed copper. A drift will be driven to explore this bed, as diamond drilling indicated that it was mineralized. In a crosscut west from drift No. 2 south conglomerate No. 16, the Hancock No. 3 and the Atlantic lodes were cut but were barren.

In sinking the main winze or shaft from the 190 foot level there was some copper showing for about the first 15 or 20 feet but not in any large amount until a depth of about 370 feet was reached. In the winze at this depth some good bunches of copper were found. In the north drift on the 400 foot level the copper showing was fair. In a crosscut northwest from the south drift on the 400 foot level several feet of good looking ore was disclosed, about eight or ten feet in the hanging-wall of the main lode. Work on the 400 foot level will be vigorously prosecuted.

New Arcadian Copper Company.

The general plan of development work was continued at No. 1 shaft. The shaft was sunk 333 feet and is now bottomed at a depth of 1,500 feet. Drifting was done on six levels, crosscutting on four levels, and some stoping was done on four levels. The lode appears to be very persistent, and the mineralization has been very satisfactory. The openings on the 1,500 foot level show the same persistence of mineralization at depth. The lode on the bottom level is wide, being over 20 feet in some places, and is very well charged with copper.

About 1,800 feet south of No. 1 shaft No. 2 shaft was sunk 169 feet, and 245 feet of drifting done on the Old Arcadian lode. The showing was encouraging, but on account of scarcity of labor, operations were suspended at this point.

During the year 1,391 tons of ore was shipped to the Franklin mill and yielded 32,307 pounds of refined copper. There is now several thousands tons of ore on hand which will be shipped to the Franklin mill in the spring of 1917.

New Baltic Copper Company.

The New Baltic controls 800 acres of land on the copper range in Houghton county. Diamond drilling has found several well mineralized beds, including the No. 8 conglomerate.

In the No. 7 drill hole, the last to be drilled on the property, No. 8 conglomerate was intercepted at a depth of 1,192 feet. It was found to be 41 feet thick with a dip of about 52°. Copper in varying quantities was noted in beds at 329 feet, 493 feet, 652 feet, 792 feet and also in No. 8 conglomerate at 1,196 feet.

The persistence of mineralization is indicated in the correlation of the New Baltic hole No. 7 and the New Arcadian hole No. 24, located about 500 feet to the northwest. In hole No. 24 copper was found in an amygdaloid at 790 feet, which corresponds to 493 feet in No. 7 New Baltic, and also in a bed at 980 feet, which corresponds to 652 feet in No. 7 hole. The New Arcadian lode is no doubt the bed cut at 792 feet in New Baltic No. 7 hole.

The satisfactory results of the diamond drilling led to the locating of a shaft about 500 feet southwest of the N. ¼ post of section 16, 55-33, to intercept the northerly extension of the New Arcadian lode.

Sinking of the shaft was started in October, and, after passing through about 60 feet of overburden, was finally bottomed on the desired amygdaloid bed. The shaft will be sunk as rapidly as possible, probably to a depth to correspond with the 250 foot level of the New Arcadian mine.

North Lake Mining Company.

Development work was carried on continuously throughout the year with encouraging results.

Shaft sinking was continued and in June had reached a depth of 821 feet. On the 800 foot level crosscuts were driven northwest and southeast. At the end of the year the southwest crosscut was breasted in No. 8 conglomerate and as nearly as can be calculated had 688 feet farther to go to reach the first of the South Lake lodes. These lodes were opened from the crosscut on the 300 foot level and carried copper but development work on that level was abandoned owing to breaking through into overburden at two points.

The southeast crosscut passed through a good looking amygdaloid at 679 to 728 feet from the shaft, which showed fine copper throughout. A drift is now being driven along the foot-wall to explore this lode. Results to date have been very encouraging.

The southeast crosscut will be continued indefinitely, as there are several more known copper-bearing amygdaloids to be cut by it which were discovered by diamond drilling. The one which showed the best copper in the drill cores should be cut by the crosscut at 1,480 feet from the shaft.

Old Colony Copper Company.

On December 20, 1916 the following announcement was made to stockholders of Old Colony by the directors of the company:

"Your directors desire to state that a plan has been agreed upon by the Boards of Directors of the Old Colony Copper Company and the Mayflower Mining Company for a consolidation of the two properties on an equal basis. The consolidated company will have about $100,000 as a fund with which to begin shaft sinking to develop the mineral deposit which has been disclosed on both properties by the drilling just concluded. This sum will be contributed in approximately equal amounts by the two companies, and an assessment of 50 cents per share has therefore been levied on the shares of the Old Colony Copper Company to provide its share of this fund. The consolidated company, which is to be known as 'Mayflower-Old Colony Copper Company', will have an authorized capitalization of 200,000 shares, $12.00 per share paid in, and will acquire all the property and assets of both companies on a share for share basis, and will be under the direction of Mr. H. F. Fay, identified with both companies since their organization, as President.

"The drilling campaigns heretofore conducted by both companies have developed to date a total tonnage on both properties, on an assumed dip of 50 degrees, of approximately 32,000,000 tons, and have proven the continuity of the lode for a distance of about one mile on the strike. The work has been entirely original research in a territory never before explored, but the results thus far obtained indicate that it is a lode of unusual width, and the general average of all the values shows it to be a formation with a high degree of mineralization. The drilling has encountered many puzzling geological problems, but it has been thoroughly and scientifically performed, and has developed a mineral deposit which has been most persistent in the extensive area covered by the investigation.

"The results secured to date warrant shaft sinking to open up the deposit revealed by the diamond drilling, and a consolidation is the natural solution of the question of how best to demonstrate the value of both properties, and it is apparent that through a consolidation a duplication of mining operations can be avoided and many other economies effected.

"The two companies now have sufficient machinery and equipment to carry on shaft sinking to a considerable depth and also dwellings to accommodate the force required for this work."

Onondaga Copper Company.

Diamond drilling was discontinued in the summer of 1916, and, while the treasury has ample funds to resume exploration work, it is not probable that anything will be undertaken in the immediate future.

Osceola Consolidated Mining Company.

Osceola had another profitable year in all three branches in 1916.

Osceola Branch.

The grade of ore mined was even better than in 1915, and the yield per ton was 14.89 pounds. Mining operations were limited to No. 6 shaft. The workings south of No. 6 shaft near the boundary continued in good ground all the year. The 38th and 39th levels were particularly rich; the 40th and 41st reached the boundary line and the 42nd was driven across the line into La Salle territory.

North Kearsarge Branch.

At this branch more copper was produced in 1916 than in any other year since 1911. Only two shafts operated most of the time, and snow storms in the early part of the year hindered shipments to the extent of ever two weeks' production.

Repairs in No. 3 shaft, begun in June, 1915, were completed in the summer of 1916; hoisting was resumed in June, and production gradually increased until it amounted to 450 tons per day at the end of the year.

Changes and improvements in drilling machines and drill steel were used to good effect throughout the mine. The average recovery of copper per ton of ore treated was considerably better than in recent years.

The mine is in good condition, and No. 3 shaft's production will probably be increased as fast as that of South Kearsarge falls off.

South Kearsarge Branch.

At this branch the recovery of copper per ton of ore was better than for several years, and on the whole 1916 was unusually profitable. A third more ore was produced during 1916 than was anticipated at the beginning of the year.

Mining the pillars of No. 2 shaft was continued to a limited extent, and a start was made on No. 1 shaft pillars. These pillars contain about 650,000 tons available for mining. During 1916 over a third of the ore treated came from foot-wall work, from cleaning out old stopes and from an old stock pile on the surface. With these sources exhausted, next year's product will be considerably reduced.

For premiums and bonuses see Calumet & Hecla Mining Company.

Porcupine Exploration Company.

This company was organized early in the year 1916 to explore the Nonesuch formation in the Porcupine Mountain district. The acreage controlled by the company is shown on the map of Ontonagon county.

Beginning at the N. 1/4 post of section 23, about 16 diamond drill holes were put down in sections 23, 22 and 27 of 50-44. The general direction of the line of drill holes was about S. 35° W. The angle of all the holes was 60° and the holes varied in depth from 250 to 800 feet.

The beds cut by the drill and the average dips of the beds to the southeast are as follows:

Beds	Dips Shallow	Dips Deep
Freda sandstone about	..	59
Upper Grey Shale Group about	47	59
Upper Grit	52	63
Lower Banded Shale	50	60
Quartz Banded Shale	47	57
Lower Grit	47	57
No. 1 Shale	48	59
No. 1 Sandstone	46	60
No. 2 Parting Shale	46	59
No. 2 Sandstone	54	60
Red Sandstone	50	62

In the last few holes drilled the dip changed somewhat, indicating a bend in the formation to the west. Also in the last few holes drilled the copper values changed from native copper to chalcocite. The values found occurred at the base of the No. 1 shale, in the No. 1 sandstone, in the No. 2 shale and sometimes in the No. 2 sandstone.

Mr. A. G. Ballenberg, who was in charge of the exploration work, states that the only reason work was discontinued was the lack of copper in commercial quantities.

Quincy Mining Company.

Operations of the Quincy during 1916 showed a mining income of $2,785,778.73.

There was a large amount of development work done throughout the mine, and in all of the openings the lodes developed averaged fairly well in copper. The yield of refined copper per ton of ore treated was 17½ pounds.

At the No. 2 shaft the ore was of better grade than in 1915, with the usual percentage of mass copper. The drifts on the various branches of the Pewabic lode continued throughout the year in good average grade ore. The lower levels of this shaft averaged better in copper than similar drifts during 1915.

Shafts Nos. 6 and 8 were sunk during the year. All drifts averaged well in copper, and more copper was found than in similar drifts the previous year. At No. 6 a better showing of copper is especially noticeable in the extreme lower levels.

Since about the middle of the year No. 7 shaft has been used to hoist water during a part of one shift and for Hancock operations during the other full shift.

Extensive general repairs were made to buildings and ore dressing machinery at the stamp-mills. The smelter was extremely busy throughout the year, and about November 1st the briquetting plant, which had been idle for over five years, was again started in order to increase the capacity of the works.

Seneca Mining Company.

On April 13, 1916 the announcement was made that a syndicate composed of Thomas F. Cole, of Duluth, Tucker, Hayes & Bartholomew, with some associates, had secured control of over 60 per cent of the stock of the Seneca Mining Company, control of which was owned by the Calumet & Hecla Mining Company. The Seneca adjoins the Mohawk and Ahmeek and carries the Kearsarge lode on the dip.

It was further announced that a new corporation would be organized having 200,000 shares of stock. Thomas F. Cole was to be president of the new company and W. J. Uren, general manager. Immediate operations were planned to develop the south end of the property by sinking a shaft. This deal, however, did not materialize for various reasons.

In the early part of December announcement was made that Tucker, Hayes & Bartholomew, in association with Lewisohn Brothers of New York, had secured a renewal of the option from the Calumet & Hecla, carrying control of the Seneca Mining Company. It was proposed to form a new company, the Seneca Copper Company, with 250,000 shares, 200,000 shares to be issued at $15 per share. W. J. Uren was named as general manager.

On December 23, 1916 the Calumet & Hecla sold its 11,207 shares of Seneca for $60 a share, receiving $672,420. In making this sale, it was stipulated that the other shareholders should receive an offer of $60 a share for their shares, provided they were presented within a reasonable time.

Operations at the new Seneca will probably be begun in the spring of 1917 under the direction of W. J. Uren.

South Lake Mining Company.

South Lake continued development work, and total openings up to the end of the year 1916 show approximately one mile of drifts on the various lodes, a large proportion of the ground opened being of suitable character for stoping.

The long drift on No. 3 east at the 600 foot level south is being driven to make a connection with the Lake mine. This drift has opened considerable stretches of very good ground.

Production began in May with 627 tons of ore treated at the Franklin mill. This amount was increased gradually to 3,500 tons in December; a total of 20,057 tons being sent to the mill in the eight months from May to December inclusive. This 20,057 tons yielded, including mass, 476,280 pounds of concentrates. The estimated yield of refined copper is 285,600 pounds.

A steel rockhouse of modern design was constructed and is now in successful operation. Production during the first month of 1917 will probably be increased to double the average for the last eight months of 1916.

Superior Copper Company.

Operations during 1916 were confined to No. 1 shaft; no new work was attempted at No. 2 shaft during the year.

On the 17th level in the Superior lode, the last two available stopes are now being mined, and, with the exception of one stope on the 15th level, all ground above this point has been worked out.

On the 18th, 19th, 20th and 21st levels in the West lode, about 1,800 feet of drifts show copper ground of apparent value, representing about 150,000 tons of ore, stoping of which has not yet been started. If to this tonnage is added about 100,000 tons which remains in present active stopes, there is a total of approximately 250,000 tons still to be mined. This available ore lies within the only copper shoot evident in the lower drifts. The shoot has been found to extend from the 18th to the 21st levels and lies about 1,200 feet south of No. 1 shaft. It has not, however, shown sufficient size to warrant driving such long drifts in order to reach it, and it has therefore been decided to sink to the 33d level before conducting the further explorations which will probably determine the future of the mine.

During 1916 the shaft was sunk for the most part in trap rock between the Superior and West lodes. The shattered nature of the ground retarded sinking considerably, and the sinking was discontinued temporarily at a point below the 29th level. Sinking will be resumed as soon as possible and will be continued to the 33d level, at which point an extensive exploration of the various lodes will be conducted.

Tamarack Mining Company.

Tamarack's production for 1916 was nearly double that of 1915. The yield of refined copper per ton of ore treated was 18.2 pounds compared with 17.9 pounds in 1915. Good ground was opened in the newer stopes at the North Tamarack branch.

Tamarack made a good profit, although costs were very high. The regrinding plant at the mill was completed in the summer, but no machinery has as yet been installed.

The Tamarack mine is deep, and mining is expensive, but operated on a large scale and probably at considerable initial expense, Tamarack could make a profit even on 15 cent copper.

In the latter part of 1915 the Calumet & Hecla suggested that it might consider a purchase of the Tamarack property if an agreement could be reached as to its value. Mr. W. E. Parnall was accordingly employed by the Tamarack to examine and report on the value of the property. Mr. Parnall reported a valuation of the assets, other than ore in the ground, at $4,616,734, from which would be deducted the company's debts of $349,286. He found it impossible to place a value on the ore deposits. Mr. Parnall was of the opinion that a different method of mining on a large scale would be profitable.

Mr. MacNaughton, general manager of the mine, believed that it would not pay to operate Tamarack because of the high costs. He did not consider the unopened ore bodies of any value and did not believe that increasing the production would be profitable.

The result of several months' negotiations was that the Calumet & Hecla offered to purchase all the assets of the Tamarack, except its holdings of Mineral Range Railroad stock, for $3,563,486, and to assume and pay the existing debts of the company. That meant $59 a share to Tamarack stockholders. The offer was conditional upon the completion of the sale and delivery of the Tamarack property by June 1, 1916.

The sale was blocked by G. A. Hyams, a stockholder of the Tamarack. Late in August the directors of the Calumet & Hecla determined that under existing circumstances it was for the best interests of the company to distribute among its stockholders its holdings of Tamarack stock. A dividend was declared of 20,000 shares of the capital stock of Tamarack to be delivered to stockholders on August 31, 1916, at the rate of one-fifth of a share of the capital stock of the Tamarack for each share of the stock of the Calumet & Hecla. This distribution of Tamarack stock by the Calumet & Hecla to its shareholders was followed by the resignation of James

MacNaughton as general manager of the Tamarack. Mr. Charles S. Smith was elected president and Charles H. Altmiller, secretary and treasurer of the Tamarack company, and the main offices were removed to 50 Congress Street, Boston.

Tremont and Devon Mining Company.

The Tremont and Devon adjoins the Victoria to the west. In the spring of 1916 diamond drill exploration was started on the property, and three holes were drilled before the work was discontinued.

It is reported that in the first hole drilled the Devon lode was cut, showing 11 feet of good ore, and that in the third hole drilled the Forest lode was cut, showing nine feet of excellent ore. In this third hole the Devon lode, which is just above the Forest lode, did not show commercial values.

Trimountain Mining Company.

Trimountain's production for 1916 showed an increase of 417,662 pounds over that of 1915. Underground openings maintained the average quality. The use of waste stamp-sand for filling stopes was begun towards the end of the year, and a total of 17,700 cubic yards was run into the mine through old No. 1 shaft. Electric haulage was installed underground on several levels.

In March the stamp-mill was destroyed by fire. Fortunately there was sufficient surplus stamping capacity at the Baltic mill to treat the output of Trimountain, so no loss of production resulted.

Victoria Copper Mining Company.

Victoria made a record production of 1,661,832 pounds in 1916. Profit from mining operations was $176,806.56. The company, however, carried on considerable construction work which reduced the profit for the year to $85,330.87.

The improvements for increasing production made during the year consist of a new shaft to the 2,600 foot level, doubling of the shaft-house and equipment, doubling of the rockhouse and rock crushing capacity, a new Nordberg hoist and an auxiliary steam power plant at the stamp mill to supply power at times when the water is low. There is now shaft and hoisting capacity to take care of all exploration and development work in opening the mine to a depth of 5,000 feet.

The copper content per ton of ore stamped increased slightly. Stopes on the 23d, 24th and 26th levels were heavy producers throughout the year, and the other stopes throughout the mine were about normal. Very little development work was done during 1916.

With the new hoist now in operation, production in 1917 should show a marked increase.

White Pine Copper Company.

No. 2 vertical shaft was sunk to a point 151 feet below the 2d level. The collar of this shaft is 150 feet north of the main fault which is almost vertical. The lodes on the south side of the fault have been found by diamond drilling to be from 600 to 700 feet lower than the lodes on the north side. To further explore the lodes on the south side, No. 2 vertical shaft is now being sunk to a point 600 feet below surface, where it will be deflected southward along a curve of 500 feet radius and should enter the lode south of the fault at a point 970 feet from surface. From this point the shaft will follow the lode which dips at an angle of 45° to 50°.

No sinking was done at shafts Nos. 3 and 4. Drifts to east and west of No. 3 shaft showed fair or average values. The 4th and 5th levels west disclosed ground of poor quality and a much faulted lode.

At No. 4 shaft drifts were extended on all six levels. The greater part of the ground opened by these drifts is poor, with average ground showing in a few places.

Considerable diamond drilling was done during the year to locate the lodes south of the fault. A deep surface hole and four underground holes have cut the lodes. These holes are located from 100 to 200 feet south of the fault and are spread along a line parallel to the fault for over 2,400 feet. As mentioned above, this drilling has shown the lodes south of the fault to lie from 600 to 700 feet lower than those immediately north of the fault.

The average yield of refined copper per ton of ore treated was 22.27 pounds in 1916.

No changes were made at the stamp-mill during the year. A 50-ton Minerals Separation flotation unit is on the ground, preparatory to testing its efficiency in saving fine copper.

For premiums and bonuses see Calumet & Hecla Mining Company.

White Pine Extension Copper Company.

White Pine Extension is developing three mineralized beds of the Nonesuch formation. These beds are known as No. 1 shale, No. 2 shale and No. 3 sandstone. No. 1 shale is a wide shale, five feet along the foot of it assays about 15 pounds of copper per ton. Below this shale, with six feet of barren sandstone intervening, is No. 2 shale, four and one-half feet in width, assaying from 22 to 30 pounds per ton. About nine feet below the No. 2 shale, as exposed in underground crosscutting, is a fine-grained sandstone, 18 to 24 inches thick, assaying as high as 60 pounds per ton in some openings.

A vertical shaft has been sunk to a depth of 242 feet, 23 feet of which was through overburden. At a depth of 55 feet a crosscut was driven into the hanging of the shaft for a distance of 30 feet, exposing both No. 1 and No. 2 shale. No. 2 shale was drifted upon for 24 feet.

At a depth of 219.8 feet the second level was established, and a crosscut was driven in to the hanging for a distance of 45 feet. At the end of the year No. 2 shale had been drifted upon for a distance of 327 feet north and 338 feet south.

At intervals of 100 feet crosscuts were made from the drift on No. 2 shale into the hanging, exposing No. 1 shale, and at 100 feet north and 100 feet south of the shaft crosscuts were driven into the foot, showing the No. 3 sandstone. It is intended to continue this system of exploration on No. 1 shale and No. 3 sandstone by crosscuts as the drifts on No. 2 shale are extended.

A site has been selected for a 100-ton experimental mill, and plans for the mill are now under consideration in accordance with recommendations by T. G. Chapman of Tucson, Arizona. Prof. Chapman obtained a recovery of 85 per cent from White Pine Extension ore in the metallurgical laboratory of the Michigan College of Mines, by a combined process of slime tables and oil flotation.

Winona Copper Company.

Openings at Winona during 1916 showed about the usual run of ground, those in No. 1 King Philip, showing perhaps the best. By increasing the size of motors driving the Hardinge mills and using steel balls instead of flint pebbles, the amount ground in each mill was materially increased.

During the year a wooden shaft and rockhouse was constructed at King Philip No. 1 shaft.

The total production of refined copper in 1916 was considerably higher than in 1915, but the yield of copper per ton of ore treated dropped to 13.39 pounds.

Wolverine Copper Mining Company.

Wolverine's production for the year ending June 30, 1916, with the exception of 1913-1914, was the lowest since the year 1901-1902. This decrease in production was due to severe winter storms, heavy rains in the spring and to a shortage of labor for some months.

Openings made during the year showed fair to good mineralization. In addition to regular stoping and drifting, about 50 per cent of the ore hoisted was obtained by cutting out the lode along the foot in older and more recent stopes.

President Stanton states that the decrease in copper contents of ore is noticeable as the bottom limits of the company's territory are approached, but as the ore is of considerable commercial value, the mine will be opened to the bottom. It will require two years or longer to reach the bottom of the mine, and the directors believe that it will then require all of ten years to exhaust the mine, estimating a production equal to the average of the past three or four years.

Wyandot Copper Company.

Work during the year ending March 31, 1917 was confined largely to stoping on the 8th and 9th levels both east and west of the winze. Drifts on the 10th level were extended both east and west of the winze, and some drifting was also done on the 8th level drift west of the winze, all with more or less encouragement.

Supt. F. L. Van Orden states as follows:

"Our showing has been too encouraging to close the exploration without further investigation, yet, on the other hand, it has not been sufficiently encouraging to warrant us in assuming or believing we have an embryo mine."

Further efforts will be confined to drifting only, east and west of the winze. The 10th level drift west carries copper in more persistent quantities than any other opening to date.

During the year a mill test was made of 1,605 tons of ore which refined 12.54 pounds of copper per ton, with 5.26 pounds left in the tailings.

A large storage bin is filled with selected ore ready for milling, and in addition to this there is some selected tonnage underground. A second mill test at a mill equipped with regrinding machinery should show much better results than the first test.

LIST OF ACTIVE COPPER MINING

Name of Company.	Location of Mine or Property.
Adventure Consolidated Copper Co.	Greenland, Ontonagon Co.
Ahmeek Mining Co.	Akmeek, Keweenaw Co.
Algomah Mining Co.	Lake Mine, Ontonagon Co.
Algonac Mineral Development Co.	Porcupine Mt. District, Ontonagon Co.
Allouez Mining Co.	Allouez, Keweenaw Co.
Baltic Mining Co.	South Range, Houghton Co.
Calumet & Hecla Mining Co.	Calumet, Houghton Co.
Carp Lake Mining Co.	Porcupine Mt. District, Ontonagon Co.
Cass Copper Co.	West of Victoria, Ontonagon Co.
Centennial Copper Mining Co.	Calumet, Houghton Co.
Champion Copper Co.	Painesdale, Houghton Co.
Cherokee Copper Co.	Between Indiana & Winona, Ontonagon Co.
Contact Copper Co.	Elm River, Houghton Co.
Copper Range Co.	Painesdale, Houghton Co.
Flint Steel	Between Michigan & Mass Mines, Ontonagon Co.
Franklin Mining Co.	Demmon, Houghton Co.
Hancock Consolidated Mining Co.	Hancock, Houghton Co.
Houghton Copper Co.	North of Superior Mine, Houghton Co.
Indiana Mining Co.	Indiana, Ontonagon Co.
Isle Royale Copper Co.	Houghton, Houghton Co.
Keweenaw Copper Co.	Phoenix, Keweenaw Co.
Lake Copper Co.	Lake Mine, Ontonagon Co.
La Salle Copper Co.	South of Osceola Mine, Houghton Co.
Mass Consolidated Mining Co.	Mass, Ontonagon Co.
Mayflower Mining Co.	East of Wolverine Mine, Houghton Co.
Michigan Copper Mining Co.	Rockland, Ontonagon Co.
Mohawk Mining Co.	Mohawk, Keweenaw Co.
Naumkeag Copper Co.	Houghton, Houghton Co.
New Arcadian Copper Co.	East of Quincy Mine, Houghton Co.
New Baltic Copper Co.	East of Franklin Mine, Houghton Co.
North Lake Mining Co.	Lake Mine, Ontonagon Co.
Old Colony Copper Co.	East of Calumet, Houghton Co.
Onondaga Copper Co.	Porcupine Mt. District, Ontonagon Co.
Osceola Consolidated Mining Co.	Osceola, Kearsarge, Tamarack, Houghton Co.
Porcupine Exploration Co.	Porcupine Mt. District, Ontonagon Co.
Quincy Mining Co.	Hancock, Houghton Co.
South Lake Mining Co.	Greenland Jc., Ontonagon Co.
Superior Copper Co.	North of Baltic Mine, Houghton Co.
Tamarack Mining Co.	Calumet, Houghton Co.
Tremont & Devon Mining Co.	West of Victoria, Ontonagon Co.
Trimountain Mining Co.	Trimountain, Houghton Co.
Victoria Copper Mining Co.	Victoria, Ontonagon Co.
White Pine Copper Co.	Porcupine Mt. District, Ontonagon Co.
White Pine Extension Copper Co.	Porcupine Mt. District, Ontonagon Co.
Winona Copper Co.	Winona, Houghton Co.
Wolverine Copper Mining Co.	Kearsarge, Houghton Co.
Wyandotte Copper Co.	East of Winona, Houghton Co.

COMPANIES OF MICHIGAN, 1916.

General Office.	General Manager.	Superintendent.
32 Broadway, New York		E. W. Walker.
12 Ashburton Place, Boston	James MacNaughton	S. Russell Smith.
60 Congress St., Boston	R. M. Edwards	Thomas Bennett.
1905 Dime Bank Bldg., Detroit		Fred B. Close.
12 Ashburton Place, Boston	James MacNaughton	F. W. Ridley.
82 Devonshire St., Boston	F. W. Denton	Albert Mendelsohn.
12 Ashburton Place, Boston	James MacNaughton	John Knox.
Houghton, Mich		Jerry Rourke.
Houghton, Mich		A. H. Meuche.
12 Ashburton Place, Boston	James MacNaughton	F. W. Ridley.
82 Devonshire St., Boston	F. W. Denton.	
Houghton, Mich	W. A. Hodgson	J. A. Thomas.
70 State St., Boston		G. S. Goodale.
82 Devonshire St., Boston	F. W. Denton	
		Samuel Brady.
60 Congress St., Boston	R. M. Edwards	Enoch Henderson.
Hancock, Mich	John L. Harris	
705 Sears Bldg., Boston		R. R. Seeber.
60 Congress St., Boston	R. M. Edwards	Thomas Bennett.
12 Ashburton Place, Boston	James MacNaughton	James E. Richards.
Calumet, Mich	W. J. Uren	
82 Devonshire St., Boston		E. W. Walker.
12 Ashburton Place, Boston	James MacNaughton	Ole Hallingby.
79 Milk St., Boston		E. W. Walker.
705 Sears Bldg., Boston		G. S. Goodale.
15 William St., New York		Samuel Brady.
15 William St., New York	Theo. Dengler	W. F. Hartman.
61 Broadway, New York		S. S. Lang.
Houghton, Mich	R. H. Shields	Otto Lieber.
Houghton, Mich	R. H. Shields	
60 Congress St., Boston	R. M. Edwards	Thomas Bennett.
705 Sears Bldg., Boston		G. S. Goodale.
Houghton, Mich	R. C. Pryor	H. W. Fesing.
12 Ashburton Place, Boston	James MacNaughton	F. H. Haller.
1517 Conway Bldg., Chicago		A. G. Ballenberg.
32 Broadway, New York	Chas. L. Lawton	
60 Congress St., Boston	R. M. Edwards	Thomas Bennett.
12 Ashburton Place, Boston	James MacNaughton	Ocha Potter.
12 Ashburton Place, Boston	James MacNaughton	J. T. Been.
Calumet, Mich	W. H. Gibson	
82 Devonshire St., Boston	F. W. Denton	Roy Reynolds.
60 Congress St., Boston		George Hooper.
12 Ashburton Place, Boston	James MacNaughton	Thos. H. Wilcox.
15 William St., New York	Theo. Dengler	W. R. Bolley.
705 Sears Bldg., Boston		R. R. Seeber.
15 William St., New York	Theo. Dengler	W. R. Bolley.
68 Devonshire St., Boston		F. I. Van Orden.

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINING COMPANIES IN 1916.

	Tons of ore treated.	Cost of mining, transportation, and stamping per ton.	Pounds of concentrate obtained.	Pounds of refined copper produced.	Per cent of refined copper in concentrate.	Pounds of refined copper per ton of ore treated.	Cost per pound at mine, excluding construction.	Cost per pound, construction.	Cost per pound smelting, freight, commission and eastern office.	Cost per pound interest paid.	Other costs per pound.	Total cost per pound.	Price received for copper sold.
Adventure				19,500									30.0c
Ahmeek	1,164,010	$1.46		24,142,158		20.7	7.04c	1.33c	3.17[1]			11.54c	25.72c
Allouez	566,960	1.589		10,219,290		18.02	8.82	0.21	1.82			10.85	25.305
Baltic	369,287	3.36		12,425,804		33.65	9.26		0.85		0.74c	10.85	25.28
C. & H. (all ore)[2]	3,166,274	2.03		71,349,591		22.53		0.60				11.63	25.48
C. & H. (conglomerate)	1,727,794	2.63		51,785,016		29.97						10.75	
C. & H. (Osceola lode)	1,438,480	1.32		19,564,575		13.60						11.84	
Centennial	150,617	1.916		2,367,400		15.72	12.18		1.26			13.44	25.02
Champion	936,656	2.42		33,601,136		35.87	6.08		1.06		0.66c	7.80	25.28
Franklin	267,286			3,116,566									25.432
Hancock	203,112			2,824,934		13.908							28.093
Houghton	19,444.35		365,880	204,274		10.55							29.21
Isle Royale	925,419	1.53		12,412,111		13.4	11.38	0.71	3.10[1]	0.05c	0.51c	15.75	25.86
Keweenaw	6,915		105,694	68,880		9.96							
Lake	70,440		2,346,970	1,489,247	63.454	21.14							29.726
La Salle	144,829	1.79		1,380,352		9.53	18.80	0.01	2.12	0.03		20.96	25.68
Mass	287,900		7,314,630	4,752,588	64.97	16.51						15.37	26.276
Mohawk	664,547	1.54	18,468,100	13,834,034	74.91	20.82	7.35		1.17			8.85	25.28
New Arcadian	1,391			32,307									24.0
Osceola	1,284,681	1.36	26,901,015	19,586,501	72,809	15.2	8.91	0.34	2.44[1]			11.69	25.73
Quincy	1,204,026		33,864,280	21,065,612		17.5							25.5
South Lake	20,057		476,280	285,600[3]									
Superior	185,315	2.07		3,034,656		16.38	12.62		1.99			14.61	24.67
Tamarack	363,649		9,477,943	6,618,507	69.0	18.2							
Trimountain	349,504			8,720,558		24.94	9.95		0.89		0.26	11.10	25.28

Victoria	146,690	....	2,568,396	1,661,832	....	....	....	......	......	......	......	....	....
White Pine	188,890	2.082	....	4,207,449	....	22.27	9.35	0.42	2.82	0.11	......	12.70	25.26
Winona	161,828.55	....	3,700,180	2,167,255	....	13.39	....	......	......	......	......	....	28.03
Wolverine (1915-16)	388,898	1.39	9,127,790	6,641,492	72.74	17.07	8.11	0.11	1.32	......	......	9.54	20.62
Wyandot	1,605	....	....	19,973	....	12.54	....	......	......	......	......	....	25.75
Totals	6,406,504.90	....	114,717,158	339,599,198	....	....	....	......	......	......	......	....	....

[1]This increase is due mainly to the extraordinary advance in ocean freight rates and marine and war risk insurance during 1916.
[2]Besides the mine production 5,412,649 pounds was recovered from the sand bank at Torch Lake.
[3]Estimated.

SUMMARY OF FINANCIAL STATEMENTS OF MICHIGAN COPPER MINING COMPANIES FOR 1916.

	Balance of Assets (+), Liabilities (−), December 31, 1915.	Operation Expenditures.	Receipts.			Net Profits from Operations.	Paid in Dividends.	Balance of Assets (+), Liabilities (−), December 31, 1916.
			Sale of Copper.	Sale of Silver.	Assessments.			
Adventure	+$1,357.79	$61,625.17	$5,850.00		$84,628.50			+$53,783.73
Ahmeek	+1,583,654.13	2,785,781.47	6,210,244.67	$16,503.60		$3,449,709.52	$2,800,000.00	+2,233,363.65
Algomah	−18,133.65	26,044.53			70,000.00			+26,470.14
Allouez	+963,810.83	1,109,168.55	2,586,011.13	47,668.20		1,524,510.78	900,000.00	+1,545,813.56
Atlantic	+246,329.89	10,847.75			60.00	13,327.45		+259,657.34
Bohemia	+128,741.30	3,259.11				899.08		+131,087.86[1]
Baltic	+1,440,516.25	1,379,943.53	3,141,243.25			1,792,667.75		+3,233,184.00
Calumet & Hecla	+8,256,445.92						7,500,000.00	+10,758,601.75[2]
Centennial	+273,118.50	318,268.42	592,268.76			276,546.26	90,000.00	+448,368.48
Champion	+1,815,868.46	2,638,194.31	8,494,367.18			5,870,606.26	6,014,540.96	+1,671,933.76
Cherokee	+39,791.62							
Cliff	+24,113.49	3,278.34						+21,335.14
Contact	+18,948.96	18,937.16						+5,922.50
Copper Range	+3,390,463.21	5,098,593.80	13,840,167.49			6,078,189.65	3,941,648.00	+5,558,460.25
Franklin	+30,022.43	642,521.15	792,623.00			162,071.95		+192,094.02
Hancock		771,514.86	755,946.16		117,016.00	103,687.70		
Houghton	+24,763.49	78,694.63	27,714.61		3,520.00			+24,419.50
Indiana	+14,574.35	46,178.93						−30,236.62
Isle Royale	+414,524.88	1,865,968.93	3,209,537.18	53,086.76		1,396,655.01	750,000.00	
Lake	+254,164.08	342,302.56	442,696.25			108,194.94		+362,359.02[3]
La Salle	+94,636.49	289,397.94	354,409.23	13,843.80		78,855.09		+173,491.58
Laurium	−19,312.88	5,159.91						−24,472.79
Mass	+213,361.07	825,367.97	1,248,779.94	1,359.37		430,527.95	194,634.00	+449,255.02
Mayflower	+52,990.74	17,728.87			7,081.00			+45,314.09
Michigan	−117,907.16	82,625.40	16,074.52		25,960.82			−158,497.22
Mohawk	+1,763,784.71	1,226,805.76	3,496,860.09			2,270,054.33	1,700,000.00	+2,333,839.04
New Arcadian	+66,742.93	118,415.47	7,753.68		24,140.50			+21,315.53
New Baltic	+20,360.92	60,882.38			60,659.00			+21,648.34
North Lake	−15,556.20	56,188.99			100,000.00			+28,587.47
Old Colony	+35,666.75							

Onondaga	+46,585.10								
Osceola	+1,728,237.33	2,288,974.46	5,040,012.69			2,776,159.55	1,826,850.00	+2,677,546.88
Pacific	+26,939.36	271.53						+27,706.71
Quincy	+1,664,956.46	2,663,176.30	5,374,715.32	26,159.19		2,758,658.89	1,760,000.00	+2,663,615.35
South Lake	+16,958.11	173,717.94	37,129.63					+2,212.17
St. Mary's	+289,544.32						480,000.00	+56,104.26
Superior	+216,274.86	443,532.05	748,732.40	26,732.72		331,933.07	100,000.00	+434,312.98
Tamarack	+1,204,980.94							
Trimountain	+1,158,144.13	992,575.24	2,204,557.06			1,236,048.91		+2,492,088.59
Union Copper	+13,745.45							+15,389.97
Victoria	+112,280.45	384,898.04	293,296.84			85,330.87		+197,611.32
White Pine	+139,786.05	534,136.79	1,062,802.29	62,131.83		590,797.33	116,675.63	+613,907.75
White Pine Extension		113,833.99						+48,233.19
Winona	+223,324.11	545,201.97	473,583.08		9,044.00			+330,045.30
Wolverine	+787,310.67	634,067.94	1,369,285.99			735,218.05	660,000.00	+862,528.72[4]
Wyandot	+23,733.04	48,304.69	5,143.05		26,268.00			+16,643.63[5]

[1]For year ending Feb. 28, 1917.
[2]Dividends received from other mining companies amounted to $2,226,930.
[3]For year ending April 30, 1917.
[4]For year ending June 30, 1916.
[5]For year ending March 31, 1917.

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINING COMPANIES IN 1912-1916.

	Tons of ore treated.	Cost of mining, transportation, and stamping per ton.	Pounds of concentrate obtained.	Pounds of refined copper produced.	Per cent of refined copper in concentrate.	Pounds of refined copper per ton of ore treated.	Cost per pound at mine, excluding construction.	Cost per pound, construction.	Cost per pound smelting, freight, commission and eastern office.	Cost per pound interest paid.	Other costs per pound.	Total cost per pound.	Price received for copper sold.
Ahmeek:													
1916	1,164,010	$1.46	....	24,142,158	....	20.7	7.04c	1.33c	3.17c	....	....	11.54c	25.72c
1915	948,874	1.26	32,292,325	21,800,492	67.50	23.0	5.48	0.81	1.67	....	....	7.96	18.28
1914	590,519	1.55	20,333,000	13,634,605	67.06	23.1	6.73	1.68	1.30	....	....	9.71	13.08
1913	383,749	1.77	13,742,140	9,220,874	67.10	24.0	7.38	4.53	1.39	....	....	13.30	15.42
1912	652,260	1.39	23,945,315	16,455,769	68.72	25.2	5.51	1.20	1.14	....	....	7.85	16.61
Allouez:													
1916	566,960	1.589	....	10,219,290	....	18.02	8.82	0.21	1.82	0.00	....	10.85	25.305
1915	534,705	1.365	14,506,440	10,043,459	69.23	18.78	7.27	0.19	1.84	0.01	....	9.31	18.166
1914	354,457	1.583	9,408,470	6,056,548	64.37	17.09	9.26	0.00	1.83	0.09	....	11.18	12.853
1913	236,663	1.687	6,640,000	4,091,129	61.61	17.29	9.76	0.16	1.94	0.23	....	12.09	15.672
1912	333,618	1.613	8,787,120	5,525,455	62.88	16.56	9.74	1.60	1.87	0.31	....	13.52	16.668
Baltic:													
1916	369,287	3.36	....	12,425,804	....	33.65	9.26	....	0.85	....	0.74c	10.85	25.28
1915	378,443	2.73	....	12,028,947	....	31.79	8.13	....	0.92	....	0.45	9.50	17.40
1914	324,433	2.17	....	7,001,945	....	21.58	9.90	....	1.11	....	0.16	11.17	13.38
1913	333,289	2.52	13,282,825	7,736,124	....	23.21	....	....	....	....	....	11.91	14.89
1912	652,433	2.05	22,444,810	13,373,961	....	20.50	8.89	....	0.87	....	1.18	10.94	16.16
C. & H. (all ore):													
1916	3,166,274	2.03	....	71,349,591	....	22.53	....	0.60	....	....	....	11.63	25.48
1915	3,188,583	1.71	....	71,030,518	....	22.28	....	0.47	....	....	....	9.33	18.11
1914	2,592,462	1.85	....	53,691,562	....	20.70	....	1.00	....	....	....	11.35	14.01
1913	2,035,625	2.38	....	45,016,890	....	22.11	....	1.54	....	....	....	14.25	15.77
1912	2,806,610	1.91	....	67,856,429	....	24.18	....	0.80	....	....	....	9.86	16.65

C. & H. (Conglomerate):													
1916	1,727,794	2.63		51,785,016		20.97						10.75	
1915	1,739,984	2.13		51,738,588		29.74						8.69	
1914	1,439,986	2.37		37,996,045		26.38						10.42	
1913	1,175,259	2.99		32,731,768		27.85						12.67	
1912	1,746,960	2.23		51,935,245		29.73						8.87	
C. & H. (Amygdaloid):													
1916	1,438,480	1.32		19,564,575		13.60						11.84	
1915	1,448,599	1.07		19,291,930		13.32						9.71	
1914	1,152,476	1.19		15,695,517		13.62						10.20	
1913	842,162	1.53		12,051,238		14.31						12.62	
1912	1,040,600	1.36		15,692,199		15.08						10.36	
Centennial:													
1916	150,617	1.916		2,367,400		15.72	12.18		1.26	0.00		13.44	25.02
1915	150,191	1.753	3,029,880	2,347,500	77.48	15.63	11.21		1.16	0.08		12.45	18.145
1914	138,136	1.838	3,311,780	2,287,130	69.06	16.56	11.10		1.11	0.35		12.56	12.111
1913	85,443	2.179	2,324,040	1,612,262	69.37	18.87	11.55		1.37	0.46		13.38	15.358
1912	106,517	1.92	2,567,385	1,742,338	67.86	16.36	11.74		1.32	0.40		13.46	16.982
Champion:													
1916	936,656	2.42		33,601,136		35.87	6.08		1.06		0.66	7.80	25.28
1915	923,743	1.95		33,417,599		36.17	5.12		0.90		0.28	6.30	17.40
1914	614,854	2.11		15,807,206		25.71	7.92		0.98		0.31	9.21	13.38
1913	421,849	2.788	19,251,470	12,080,594		28.64						10.71	14.89
1912	765,306	1.785	28,460,500	17,225,508		22.508	7.22		0.92		0.74	8.88	16.16
Franklin:													
1916	267,286			3,116,566									25.432
1915	122,018			1,314,969									19.83
1914	7,324		175,944	93,283		12.73							13.99
1913	123,179			1,021,440									15.427
1912	176,462			1,710,651		9.80							16.794
Hancock:													
1916	203,112			2,824,934		13.908							28.093
1915				871,124									18.57
1914				488,678									13.389
1913													
1912													

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINING COMPANIES IN 1912-1916.—*Continued.*

	Tons of ore treated.	Cost of mining, transportation, and stamping per ton.	Pounds of concentrate obtained.	Pounds of refined copper produced.	Per cent of refined copper in concentrate.	Pounds of refined copper per ton of ore treated.	Cost per pound at mine, excluding construction.	Cost per pound, construction.	Cost per pound smelting, freight, commission and eastern office.	Cost per pound interest paid.	Other costs per pound.	Total cost per pound.	Price received for copper sold.
Houghton:													
1916	19,444.35	......	365,880	204,274	......	10.55	......	......	......	......	......	......	......
1915	14,656.92	......	285,900	156,766	......	10.69	......	......	......	......	......	......	29.21
1914	......	......	......	......	......	......	......	......	......	......	......	......	22.2
1913	......	......	......	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......	......	......	......
Isle Royale:													
1916	925,419	1.53	......	12,412,111	......	13.4	11.38	0.71	3.10	0.05	0.51	15.75	25.86
1915	680,270	1.45	13,727,832	9,342,106	68.05	13.7	10.56	1.50	2.06	0.22	0.60	14.94	18.36
1914	474,349	1.49	9,451,115	6,601,235	69.85	13.9	10.67	0.53	1.46	0.21	0.48	13.05	13.16
1913	314,679	2.12	5,887,000	4,158,548	70.64	13.2	16.07	0.73	1.53	0.10	0.38	18.81	15.29
1912	531,105	1.54	11,461,410	8,186,957	71.43	15.4	10.01	0.20	1.31	0.09	0.28	11.89	16.66
Lake:													
1916	70,440	......	2,346,970	1,489,247	63.454	21.14	......	......	......	......	......	......	29.726
1915	59,848	......	2,511,216	1,581,071	62.96	26.42	......	......	......	......	......	......	20.149
1914	......	......	......	......	......	......	......	......	......	......	......	......	......
1913	......	......	......	......	......	......	......	......	......	......	......	......	......
1912	83,109	......	2,153,128	1,300,562	60.08	15.39	......	......	......	......	......	19.5	......
La Salle:													
1916	144,829	1.79	......	1,380,352	......	9.53	18.80	0.01	2.12	0.03	......	20.96	25.68
1915	80,959	......	......	782,493	......	9.67	......	......	......	......	......	......	18.22
1914	45,509	......	......	540,731	......	11.88	......	......	......	......	......	......	12.797
1913	2,221	......	......	43,906	......	19.76	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......	......	......	......

Mass:													
1916	287,900	....	7,314,630	4,752,588	64.97	16.51	....	......	......	......	......	15.37	26.276
1915	323,335	....	7,105,295	4,638,452	65.28	14.35	13.06	0.40	1.31	......	......	14.77	18.363
1914	209,354	....	4,487,425	2,944,952	65.62	14.07	....	......	1.394	......	0.526	13.526	12.751
1913	78,250	....	1,773,810	1,213,545	68.415	15.51	....	......	......	......	......	....	15.60
1912	132,891	....	2,985,335	2,045,006	68.50	15.39	....	......	......	......	......	....	....
Mohawk:													
1916	664,547	1.54	18,468,100	13,834,034	74.91	20.82	7.35	......	1.17	......	......	8.85	25.28
1915	829,789	1.20	20,705,600	15,882,914	76.749	19.15	6.24	0.27	0.97	......	......	7.48	17.0
1914	649,649	1.24	14,591,000	11,094,859	76.04	17.08	7.27	......	0.96	......	0.35	8.23	12.47
1913	366,458	1.64	8,018,000	5,778,235	78.8	15.76	10.42	......	......	......	......	13.22	15.36
1912	787,941	1.47	15,901,500	11,995,598	76.1	15.22	9.67	......	0.87	......	0.07	10.61	16.08
New Arcadian:													
1916	1,391	....	....	32,307	....	20.62	....	......	......	......	......	....	24.0
1915	3,845	....	....	79,209	....	....	....	......	......	......	......	....	17.856
1914	....	....	....	....	....	....	....	......	......	......	......	....	....
1913	....	....	....	....	....	....	....	......	......	......	......	....	....
1912	....	....	....	....	....	....	....	......	......	......	......	....	....
Osceola:													
1916	1,284,681	1.36	26,901,015	19,586,501	72.809	15.2	8.91	0.34	2.44	......	......	11.69	25.73
1915	1,361,089	1.18	26,777,790	19,731,472	73.686	14.5	8.17	0.41	1.44	0.01	......	10.03	18.19
1914	1,108,447	1.29	20,997,900	14,970,737	71.296	13.5	9.52	0.14	1.12	0.01	......	10.79	13.14
1913	735,044	1.60	14,945,645	11,325,010	75.775	15.4	10.39	0.77	1.14	......	......	12.30	15.50
1912	1,246,557	1.23	24,282,312	18,413,387	75.83	14.8	8.34	0.95	1.07	......	......	10.36	16.63
Quincy:													
1916	1,204,026	....	33,864,280	21,065,612	....	17.5	....	......	......	......	......	....	25.5
1915	1,269,000	....	34,251,765	22,054,813	....	....	....	......	......	......	......	....	18.0
1914	1,016,660	....	22,612,460	15,356,380	....	....	....	......	......	......	......	....	13.3
1913	804,645	....	18,161,575	12,184,128	....	....	....	......	......	......	......	15.30	15.59
1912	1,309,253	....	30,040,360	20,634,800	....	15.7	....	......	......	......	......	11.60	....
South Lake:													
1916	20,057	....	476,280	285,600	....	....	....	......	......	......	......	....	....
1915	3,993.5	....	....	61,637	15.4	....	....	......	......	......	......	....	....
1914	....	....	....	....	....	....	....	......	......	......	......	....	....
1913	....	....	....	....	....	....	....	......	......	......	......	....	....
1912	....	....	....	....	....	....	....	......	......	......	......	....	....
Superior:													
1916	185,315	2.07	....	3,034,656	....	16.38	12.62	......	1.99	......	......	14.61	24.67
1915	212,051	1.88	....	3,866,484	....	18.23	10.31	......	1.91	0.07	......	12.29	18.125
1914	191,628	1.75	....	3,217,635	....	16.79	10.41	......	2.01	0.01	......	12.43	12.645
1913	130,826	2.36	....	2,992,765	....	22.87	10.31	0.39	2.02	0.14	......	12.86	15.378
1912	172,322	2.33	....	3,921,974	....	22.76	10.23	0.31	1.97	0.24	......	12.75	16.997

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINING COMPANIES IN 1912-1916.—*Concluded.*

	Tons of ore treated.	Cost of mining, transportation, and stamping per ton.	Pounds of concentrate obtained.	Pounds of refined copper produced.	Per cent of refined copper in concentrate.	Pounds of refined copper per ton of ore treated.	Cost per pound at mine, excluding construction.	Cost per pound, construction.	Cost per pound smelting, freight, commission and eastern office.	Cost per pound interest paid.	Other costs per pound.	Total cost per pound.	Price received for copper sold.
Tamarack:													
1916	363,649	......	9,477,943	6,618,507	69.0	18.2	......	......	......	......	......	......	......
1915	217,027	2.52	6,139,824	3,888,150	63.33	17.9	14.04	0.82	2.11	0.10	......	17.07	19.10
1914	57,410	4.49	1,743,145	1,074,808	61.66	18.7	24.00	3.28	1.80	......	......	29.08	12.80
1913	227,563	2.81	6,206,295	4,168,743	67.17	18.3	15.35	......	1.25	......	......	16.60	15.45
1912	421,385	2.23	12,118,038	7,908,745	65.26	18.8	11.90	......	1.11	0.14	......	13.15	16.56
Trimountain:													
1916	349,504	......	......	8,720,558	......	24.94	9.95	......	0.89	......	0.26	11.10	25.28
1915	349,684	2.02	......	8,302,896	......	23.75	8.38	......	1.00	......	0.14	9.52	17.40
1914	227,251	2.01	......	5,048,306	......	18.21	10.78	......	1.18	......	0.25	12.21	13.38
1913	229,149	2.51	8,546,070	4,990,938	......	21.78	......	......	......	......	......	12.62	14.89
1912	366,663	2.057	12,417,575	6,980,713	......	19.04	9.32	......	0.92	......	1.49	11.73	16.16
Victoria:													
1916	146,690	......	2,568,396	1,661,832	......	......	......	......	......	......	......	......	......
1915	133,984	......	2,262,244	1,499,695	......	......	......	......	......	......	......	......	......
1914	124,842	......	2,272,430	1,486,242	......	......	......	......	......	......	......	......	......
1913	137,163	......	2,273,890	1,428,693	......	......	......	......	......	......	......	15.75	15.23
1912	131,955	......	2,033,509	1,224,911	......	9.04	......	......	......	......	......	......	......
White Pine:													
1916	188,890	2.082	......	4,207,449	......	22.27	9.35	0.42	2.82	0.11	......	12.70	25.26
1915	114,039	2.182	......	2,824,145	......	24.76	8.80	5.64	2.04	0.16	......	16.64	18.353
1914	......	......	......	......	......	......	......	......	......	......	......	......	......
1913	......	......	......	......	......	......	......	......	......	......	......	......	......
1912	......	......	......	......	......	......	......	......	......	......	......	......	......

Winona:													
1916	161,828.55	....	3,700,180	2,167,255	....	13.39	....	......	......	......	......	....	28.03
1915	102,594.05	....	3,032,045	1,722,638	....	16.79	....	......	......	......	......	....	17.4
1914	123,339	....	2,239,170	1,352,085	....	10.96	....	......	......	......	......	....	14.2
1913	120,806	....	2,467,460	1,448,737	....	11.99	....	......	......	......	......	....	15.4
1912	181,148	....	3,586,520	2,307,237	....	12.74	....	......	......	......	......	....	....
Wolverine:													
1915-16	388,898	1.39	9,127,790	6,641,492	72.74	17.07	8.11	0.11	1.32	......	......	9.54	20.62
1914-15	397,614	1.30	9,734,850	7,250,866	74.48	18.23	7.13	......	1.30	......	......	8.43	12.81
1913-14	182,127	1.92	4,606,015	3,435,459	74.59	18.86	9.85	......	1.45	......	......	11.30	14.09
1912-13	388,502	1.62	10,782,405	8,350,312	....	21.49	7.55	......	1.115	......	......	8.665	15.89
1911-12	401,308	1.58	12,164,780	9,408,960	....	23.45	6.75	......	......	......	0.836	7.586	14.10
Totals	66,831,042	....	759,856,546	356,410,010	....	....	....	......	......	......	......	....	....

9

IRON INDUSTRY.

STATISTICAL TABLES.

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.[7]

Name of Mine.	1907 and prior years.	1908	1909	1910
American (Sterling)	127,113	23,222	90,001	163,290
Ames	6,298			
Barnum (Cliff Shaft)[1]	801,851			
Bay State	16,637			
Bessemer (See Lillie)				
Bessie	59,097			
Beaufort (Ohio)	432,683	61,035	72,987	23,427
Blue (See Queen Group)				
Boston (with American)	62,542			
Braastad { Mitchell	136,636			
Braastad { Winthrop	831,445			
Breitung No. 1				
Breitung Hamatite No. 2	161,061	55,849	129,673	114,202
Buffalo[2]	217,730			
Cambria	1,814,925	85,977	136,815	150,422
Champion	4,382,873	313	11,199	18,746
Chase				
Chester (See Rolling Mill)				
Chicago	9,012			
Cleveland[3]	2,806,298			
Cleveland Hematite (Included under Cleveland)				
Cleveland Cliffs Group[4]	13,924,094	438,379	877,433	955,374
Columbia (Kloman)	94,813			
Curry	16,671			
Dalliba (Phoenix)	59,114			
Detroit	140,841			
Dexter	118,512			
Dey	2,709			
East Champion	76,002			
East New York	327,604			
Edison	893			
Edwards (See Sampson)				
Empire	40,565	53,537	108,993	53,687
Erie	8,136			
Etna	1,091			
Fitch	31,817			
Foster[5]	171,893			
Foxdale	31,447			
Gibson	16,357			
Goodrich	49,754			
Grand Rapids (Davis)	110,736			
Green Bay (See Bay State)				
Hartford	1,237,905	278,366	250,680	183,471
Himrod				
Holmes				
Hortense (North Champion)	30,574			
Home (P. and L. S.) (Now Volunteer)	26,022			
Humboldt (Washington)	713,961			
Imperial	212,982	48,231	115,478	83,404
Indiana (See Bay State)				
Iron Cliffs[6]	1,700,537			
Iron Mountain	393			
Isabella				
Jackson	3,868,453		11,060	40,320
Keystone (See East Champion)				
Lake[10]				
Lake Angeline	7,784,751	220,410	280,298	244,923
Lake Superior	14,320,173	261,955	349,435	271,445
Lillie	1,678,150	8,632	61,708	10,121
Loyd				
Lucy (McComber)	516,244	1,115	1,672	11,257
Maas	32,378	29,036	159,197	208,103
Magnetic (Stock Pile)	292			
Manganese (Negaunee)	6,359			

See foot notes 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 on page 72.

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.

1911	1912	1913	1914	1915	1916	Total
195,197	122,211	162,253	84,845	87,514	246,163	1,301,809
						6,298
						801,851
						16,637
						59,097
2,683				21,139	40,007	653,961
						62,542
						136,636
						831,445
63,497	57,085	30,994	49,590	[1]74,107	70,328	345,601
72,688	63,995	83,280	27,705	[2]76,620	80,655	865,728
						217,730
85,954	69,904	169,153	132,834	159,443	195,612	3,001,039
						4,413,131
		52,930	19,708	39,059	72,344	184,041
						9,012
						2,806,298
514,305	1,032,836	922,005	672,428	[3]631,358	1,022,461	20,990,673
						94,813
						16,671
						59,114
						140,841
						118,512
						2,709
						76,002
						327,604
						893
16,954	33,124	38,348			47,110	392,318
						8,136
						1,091
						31,817
						171,893
						31,447
						16,357
						49,754
						110,736
						1,950,422
			14,466	[4]44,669	65,029	124,164
				17,373	3,379	20,752
						30,574
						26,022
						713,961
86,959	53,943	37,543				638,540
						1,700,537
				10,807	5,893	17,093
				[5]36,255	97,368	133,623
22,303	53,559	1,519	20,241	56,026		4,073,481
167,258	151,910	102,762	128,073	19,513		9,099,898
167,352	169,326	164,834	133,519	199,920	422,473	16,460,432
25,597	26,119					1,810,327
28,003	44,224	135,746	123,211	195,975	281,502	808,661
16,676	72,724					619,688
24,926	46,664	171,475	55,903	267,190	259,897	1,254,769
						292
						6,359

See foot notes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 on page 73.

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE,[7]—*Concluded.*

Name of Mine.	1907 and prior years.	1908	1909	1910
Marquette[7]	152,847			
Mary Charlotte	717,647	99,104	240,433	197,522
Mesabi's Friend	16,043			
Michigamme[6]	880,362			
Miller	4,756			
Milwaukee-Davis	375,451			
Mitchell	17,780	11,539		23,428
Moore	68,131			
Morris				
National	150,216			
Negaunee	3,017,691	232,219	312,217	348,818
Negaunee Construction Works	12,708			
New York (York)	1,123,071			
New York Hematite	37,587			
North Champion (See Hortense)				
North Republic	289			
Nonpareil (St. Lawrence)	23,395			
Northwest	1,687			
Norwood	5,753			
Ogden	986			
Pascoe	59,806			
Pendill	45,993			
Palmer	14,172			
Palmer (Cascade) (See Volunteer)				
Pioneer	15,409			
Pittsburg & Lake Angeline (See Lake Angeline)				
Platt	73,844			
Portland			79,652	49,584
Primrose	6,040			
Prince of Wales[2]	32,415			
Quartz	491			
Queen[2]	180,866			
Queen Group[8]	4,974,391	104,098	237,509	230,119
Republic	5,948,895	67,999	176,575	150,732
Republic Reduction Co	47,174			
Richards	8,261			
Richmond	524,895	60,994	102,566	95,772
Riverside	16,160			
Rolling Mill	393,630	52,147	133,139	115,193
Saginaw	451,424			
Salisbury[5]	686,411			
Sam Mitchell (See Mitchell)				
Sampson (Argyle)	267,805			
Shadt	1,261			
Section 12	21,887			
South Buffalo[2]	245,412			
Spurr	165,244			
Star West (Wheat)	204,649			
St. Lawrence (See Nonpareil)				
Sterling (See American)				
Taylor	32,970			
Teal Lake (See Cambria)				
Titan	90,371			
Volunteer (See also Home)	1,393,175			
Washington		20,625	44,716	96,769
Webster	34,905			
West Republic	133,077			
Wetmore	50,870			
Wheeling	433,771			
Wintrhop[9]	1,335,839			
Wheat (See Star West)				
Totals	83,716,337	2,214,782	3,983,436	3,840,129

See foot notes 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 on page 72.

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.—*Concluded.*

1911	1912	1913	1914	1915	1916	Total
.....	.....	.....	.....	.....	.....	152,847
340,335	250,700	262,431	57,138	[5]159,817	164,447	2,489,574
.....	.....	.....	.....	.....	.....	16,043
.....	.....	.....	.....	.....	.....	880,362
.....	.....	.....	.....	.....	.....	4,756
7,781	11,536	10,310	.....	6,572	.....	411,650
21,387	21,141	15,970	.....	.....	.....	111,245
.....	.....	.....	.....	.....	.....	68,131
.....	1,529	18,394	29,063	80,546	58,497	188,029
.....	.....	.....	.....	.....	.....	150,216
140,040	442,190	327,447	247,484	480,521	523,735	6,072,362
.....	.....	.....	.....	.....	.....	12,708
.....	.....	.....	.....	.....	.....	1,123,071
.....	.....	.....	.....	.....	.....	37,587
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	289
.....	.....	.....	.....	.....	.....	23,395
.....	.....	.....	.....	.....	.....	1,687
.....	.....	.....	.....	.....	.....	5,753
.....	.....	.....	.....	.....	.....	986
.....	.....	.....	.....	.....	.....	59,806
.....	.....	.....	.....	.....	.....	45,993
.....	.....	.....	.....	.....	.....	14,172
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	15,409
.....	.....	.....	.....	.....	.....	73,844
.....	.....	.....	45,324	[8]97,476	.....	272,036
.....	.....	.....	.....	.....	.....	6,040
.....	.....	.....	.....	.....	.....	32,415
.....	.....	.....	.....	.....	.....	419
.....	.....	.....	.....	.....	.....	180,866
295,962	224,862	235,648	178,574	473,961	283,775	7,238,899
113,137	156,867	135,879	52,562	215,182	209,059	7,226,887
.....	.....	.....	.....	.....	.....	47,174
.....	.....	.....	.....	.....	.....	8,261
47,293	117,873	138,394	129,551	[9]177,304	181,154	1,575,796
.....	.....	.....	.....	.....	.....	16,160
96,584	115,784	163,287	98,010	[10]130,900	253,943	1,552,617
.....	.....	.....	.....	.....	.....	451,424
.....	.....	.....	.....	.....	.....	686,411
.....	.....	.....	.....	.....	.....	267,805
.....	.....	.....	.....	.....	.....	1,261
.....	.....	.....	.....	.....	.....	21,887
.....	.....	.....	.....	.....	.....	245,412
.....	.....	.....	.....	.....	.....	165,244
.....	.....	.....	.....	.....	.....	204,649
.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	32,970
.....	.....	.....	.....	.....	.....	90,371
51,240	9,008	47,220	38,438	[11]18,851	106,987	1,664,919
62,010	66,540	60,171	1,659	.....	6,631	359,121
.....	.....	.....	.....	.....	.....	34,905
.....	.....	.....	.....	.....	.....	133,077
.....	.....	.....	.....	.....	.....	50,870
.....	.....	.....	.....	.....	.....	433,771
.....	.....	.....	.....	.....	.....	1,335,839
.....	.....	.....	.....	.....	.....	.....
2,666,121	3,415,654	3,487,993	2,340,326	[12]3,778,098	4,694,669	114,137,545

See foot notes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 on page 73.

[1]Under Iron Cliffs 1890-1895; under Cleveland-Cliffs group after 1895.
[2]Under Queen group after 1890.
[3]Under Cleveland-Cliffs group after 1883.
[4]Includes Cleveland after 1883; includes Barnum, Foster, Iron Cliffs, Michigamme and Salisbury after 1895.
[5]Under Iron Cliffs 1891-1895; under Cleveland-Cliffs group after 1895.
[6]Under Cleveland-Cliffs group after 1895.
[7]Under Winthrop after 1892.
[8]Includes Buffalo, Prince of Wales, Queen and South Buffalo after 1890.
[9]Prior to 1890, see Braastad; includes Marquette after 1892.
[10]Included in Cleveland-Cliffs Group.

[1]Iron Trade Review reports 152,063 tons shipped in 1915 by Breitung Hematite No. 1 and No. 2 combined.
[2]See foot note No. 1.
[3]Iron Trade Review reports 634,837 tons shipped in 1915.
[4]Iron Trade Review reports 203,922 tons shipped in 1915 by Mary Charlotte. Figure includes Himrod shipment.
[5]See foot note No. 4.
[6]Isabella shipment not reported by Iron Trade Review.
[7]Does not include Gwinn district. Does include west end of range in Baraga county.
[8]Iron Trade Review figure.
[9]Iron Trade Review reports 177,000 tons shipped in 1915.
[10]Iron Trade Review reports 130,902 tons shipped in 1915.
[11]Iron Trade Review reports 18,850 tons shipped in 1915.
Total for Marquette range 1915, Iron Trade Review, 3,746,591 tons. See foot note No. 7.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

	1907 and prior years.	1908	1909	1910
(Austin)	195,950	111,229	125,858	188,588
Gwinn				
(Princeton) Swanzy or Chesire	1,192,204	36,033	42,934	89,441
Stegmiller			39,869	48,842
(Stephenson)	6,305	52,588	64,075	225,726
Total	1,394,459	199,850	272,736	552,597

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1907 and prior years.	1908	1909	1910
Ada (included in Ironton)				
Anvil and North Anvil	662,408	35,937	22,927	7,235
Ashland	4,867,933	259,611	259,612	231,506
Asteroid				
Aurora (Norrie-Aurora Group after 1904)	3,961,684			
Bessemer	20,889			
Blue Jacket	1,799			
Brotherton	1,552,632	96,776	103,090	102,626
Castile	8,265		26,982	20,197
Chicago	68,727			
Colby	2,221,948	58,305	170,095	194,754
Davis (Wisconsin)	103,961			
Eureka	224,148	122,324	115,662	41,611
Federal	36,443			
First National	1,997			
Geneva	7,108			
Imperial (See Federal)				
Iron Chief	12,199			
Iron Chief No. 2	551			
Iron King (See Newport)				
Ironton	479,359	92,932	277,594	109,025
Jack Pot	99,090			
Meteor (Comet)	216,367			
Mikado	811,273	86,617	99,195	52,715
New Davis (See Davis)				
Newport and Bonnie	4,257,295	579,390	1,008,354	1,182,324
Norrie-Aurora Group (after 1904)	15,994,361	773,243	977,054	1,333,006
Pabst (Norrie-Aurora Group)	2,366,583			
Palms	1,284,489			
Pike	70,255	6,303	22,174	3,324
Plymouth				
Puritan (Ruby)	109,572			50,019
Royal				
Section 13				
South Chicago				
Sparta	4,862			
Sunday Lake	1,102,133	111,130	93,712	115,486
Tilden	4,822,945	111,184	154,506	99,937
Vaughan (See Aurora) (Norrie-Aurora Group after 1904)				
Wakefield				
Wisconsin (See Davis)				
Yale (West Colby)	286,841	14,874	71,458	108,253
Total	45,658,117	2,348,626	3,402,415	3,652,918

[1]Iron Trade Review.
[2]Iron Trade Review reports 112,932 tons shipped 1915. This figure includes 17,692 tons shipped from the Minnewawa (Wisconsin).
[3]Iron Trade Review reports 1,408,516 tons shipped 1915.
[4]Iron Trade Review reports 838,875 tons shipped 1915.
[5]Iron Trade Review reports 442,422 tons shipped 1915.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

1911	1912	1913	1914	1915	1916	Total
110,839	102,530	107,365	30,493		64,521	1,037,373
230			20,159	57,910	143,708	222,007
54,442	143,519	53,479	13,607	[8]17,171		1,642,830
45,122	50,963	45,431	40,972	40,272	65,420	376,891
135,474	214,386	96,298	93,796	243,458	368,739	1,500,845
346,107	511,398	302,573	199,027	358,811	642,388	4,779,946

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

1911	1912	1913	1914	1915	1916	Total
310	55,610	238	5,771	[7]44,749	120,355	955,540
151,478	211,927	2,635	123,702	[2]94,622	70,466	6,273,492
20,569	70,239	42,419	135,120	13,468	88,867	370,682
						3,961,684
						20,889
						1,799
65,015	148,930	70,138	47,662	107,244	107,814	2,401,927
23,597	136,703	57,595	36,569	[6]75,596	131,422	516,906
				[1]30,977		99,704
41,673	245,195	305,744	291,947	315,913	423,553	4,269,127
						103,961
98,609	65,723	14,562	23,430	128,414	206,319	1,040,802
						36,443
						1,997
		31,303		34,416	86,922	159,749
						12,199
						551
63,359	173,135	166,123	51,138		148,200	1,560,865
						99,090
						216,367
		33,111	2,094	1,044	23,741	1,109,790
				5,434	4,997	10,431
555,853	966,435	1,139,666	702,861	[4]835,058	1,310,595	12,537,821
883,910	1,500,758	1,503,451	985,199	[3]1,407,770	1,855,863	27,214,615
						2,366,583
	39,152	88,644	173,792	[5]444,673	528,746	2,559,496
						102,056
					330,496	330,496
	90,683	64,463	58,410	80,367	308,534	762,048
		10,659	11,686	8,004	11,527	41,876
		3,844		32,356	48,070	84,270
				[1]1,274		1,274
						4,862
56,096	155,485	110,374	54,327	136,211	188,771	2,123,725
138,387	158,191	97,686	114,777	99,516	110,733	5,907,862
		15,261	313,050	651,302	1,061,753	2,041,366
154,944	76,772	89,482	19,074	42,632	149,155	1,013,485
2,253,800	4,094,938	3,847,398	3,150,609	4,591,040	7,316,899	80,315,830

[6]Iron Trade Review reports 76,702 tons shipped 1915.
[7]Iron Trade Review reports 45,171 tons shipped 1915.
[8]Iron Trade Review reports 40,248 tons shipped 1915.
Total for Gogebic range 1915 Iron Trade Reveiw 4,595,498 tons.
Total for Gwinn district 1915 Iron Trade Review 358,787 tons.

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1907 and prior years.	1908	1909	1910
Antoine	1,353,792			
Aragon	5,362,941	226,354	246,984	241,046
Breen	75,425			
Briar Hill	14,981			
Chapin	15,203,149	391,620	587,647	465,543
Clifford & Traders			103,626	91,081
Cornell	49,302			
Cuff	58,419			
Cundy	807,967	1,410	5,512	
Curry	416,928			
Cyclops	286,093			
Eleanor (Appleton)	18,719			
Emmett	66,655			
Forest	11,988			
Half and Half	7,524			
Hamilton	96,072			
Hersel	955			
Indiana	17,871			
Keel Ridge	93,101			
Loretto	1,085,053	13,354	96,613	116,048
Ludington	1,001,518			
Millie (Hewitt)	354,056	3,322	10,887	
Munro	227,542	27,773	23,241	20,022
Norway	1,291,352			
Penn Iron Mining Co	4,233,133	176,211	428,004	344,760
Perry	3,138			
Pewabic	6,086,946	365,341	465,453	380,376
Quinnesec	499,756		3,147	744
Saginaw (Perkins)	443,322	38,669	19,994	
Stephenson	39,350			
Sturgeon River	19,404			
Verona	130,975			
Vivian	395,356	10,056		14,827
Vulcan (with Penn Mines)	1,668,654			
Walpole	19,089			
Total	41,470,486	1,254,110	1,991,108	1,674,447
METROPOLITAN TROUGH.				
Groveland	40,036	9,123	24,933	26,462
Metropolitan	107,027			
Northwestern	35,810			
Total	182,873	9,123	24,933	26,462
CALUMET TROUGH.				
Calumet	106,132	15,222		

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

1911	1912	1913	1914	1915	1916	Total
						1,353,792
201,269	244,812	230,958	188,765	302,275	244,478	7,489,882
						75,425
						14,981
357,598	327,999	369,822	341,493	[1]385,174	557,485	18,987,500
90,940	74,144	95,311	66,329		113,362	634,793
						49,302
						58,419
						844,889
						416,928
						286,093
						18,719
						66,655
						11,988
						7,524
						96,072
						955
				52,570	44,162	114,603
						93,101
18,579	135,177	158,257	45,449	68,806	174,173	1,911,509
						1,001,518
18,556			361			387,182
9,303	20,100	18,509			17,622	364,112
						1,291,352
377,026	426,743	416,410	214,827	[2]368,451	419,340	6,985,565
						3,138
352,598	279,771	364,176	299,228	178,013	301,125	9,072,987
						503,647
						501,985
						39,350
						19,404
						130,975
5,971	28,800	27,177				482,187
						1,668,654
						19,089
1,431,840	1,537,546	1,680,620	1,156,452	1,355,289	1,871,747	55,423,645
33,758	12,468	9,251				156,031
						107,027
						35,810
33,758	12,468	9,251				298,868
	35,587	18,976				175,917

[1]Iron Trade Review reports 384,654 tons shipped 1915.
[2]Iron Trade Review reports 411,393 tons shipped 1915.
Total for Menominee range 1915 Iron Trade Review 1,397,711 tons.

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1907 and prior years.	1908	1909	1910
Alpha	1,370			
Amasa Porter				
Armenia	311,608			65,473
Balkan				
Bristol (Claire)	1,598,242	190,300	396,825	270,742
Carpenter				
Columbia	942,703			
Crystal Falls	1,733,969	296	986	
Delphic	33,770			
Dunn	1,319,646	8,829	193,396	136,144
Fairbanks	8,500			
Genesee (Ethel)	405,854		65,585	66,185
Gibson	16,357	4,548	36,246	45,202
Great Western	1,635,236	124,246	112,747	80,709
Hemlock	1,393,503	83,834	112,481	115,407
Hilltop	20,229			
Hollister	10,469	10,671	25,842	49,434
Hope	28,530			
Judson				
Kimball	16,224			
Lamont (Monitor)	555,341			3,183
Lee Peck	2,844			
Lincoln	239,970		1,657	
Magnate	6,844			
Mansfield	939,652	44,633	118,713	114,357
Mastodon	425,708			
McDonald			1,114	6,022
Michigan	153,184	603		17,922
Monongahela	9,310			
Odgers				
Paint River (Fairbanks)	371,289			
Ravenna				
Richards				
Sheldon & Shafer (Union) (See Columbia)				
South Mastodon	8,203			
Tobin	873,427	161,642	359,668	235,812
Warner				
Youngstown	151,425			
Total	13,213,407	629,602	1,425,261	1,206,592

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

1911	1912	1913	1914	1915	1916	Total
...	...	...	...	...	...	1,370
...	...	...	...	...	80,492	80,492
51,862	150,808	83,202	50,501	...	...	713,454
...	...	...	...	[5]144,284	229,195	373,479
322,729	438,900	379,169	172,006	[1]378,831	462,801	4,610,545
...	...	...	51,147	[2]284,187	240,114	575,448
...	...	...	...	...	...	942,703
...	...	...	...	...	...	1,735,251
...	...	...	...	...	...	33,770
232,092	242,304	61,080	52,883	8,304	...	2,254,678
...	...	...	...	...	...	8,500
25,342	4,248	...	...	1,184	...	568,398
56,528	...	...	...	...	...	158,881
84,338	3,342	50,464	...	35,759	...	2,126,840
107,753	126,132	113,201	46,449	[6]28,172	...	2,126,932
...	...	...	8,223	...	...	28,452
5,022	...	25,251	16,430	...	...	143,119
...	...	...	...	...	...	28,530
...	...	...	6,619	...	162,519	169,138
...	...	...	...	19,533	...	35,757
...	...	...	...	...	...	558,524
...	...	...	...	...	...	2,844
...	...	...	...	...	...	241,627
...	...	...	...	...	...	6,844
54,646	...	190,503	...	...	...	1,462,504
...	...	...	...	...	...	425,708
5,240	1,384	16,499	...	...	...	30,259
...	...	27,917	9,471	[6]112,721	28,483	350,311
...	...	...	...	...	21,920	31,230
...	...	...	...	...	53,176	53,176
...	...	...	...	...	...	371,289
127	18,303	70,766	49,308	[3]116,735	3,476	258,715
...	...	...	7,069	92,807	29,381	129,257
...	...	...	...	...	...	8,203
308,456	319,318	154,896	65,351	18,624	146,113	2,643,307
...	...	...	...	[4]46	33,751	33,797
...	...	...	...	...	...	151,425
1,254,135	1,304,739	1,172,948	535,457	1,241,187	1,491,421	23,474,757

[1]Iron Trade Review reports 378,786 tons shipped 1915.
[2]Iron Trade Review reports 284,088 tons shipped 1915.
[3]Iron Trade Review reports 116,724 tons shipped 1915.
[4]Not reported by Iron Trade Review.
[5]Not reported by Iron Trade Review.
[6]Iron Trade Review reports Hemlock 28,172 tons, Michigan 112,680 tons shipped 1915.
Total for Crystal Falls district 1915 Iron Trade Review 1,240,946 tons.

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1907 and prior years.	1908	1909	1910
Baker			45,003	39,417
Baltic	865,200	129,037	174,426	171,930
Bates				
Bengal				
Berkshire		3,440	34,295	97,999
Beta	4,211			
Caspian	236,320	102,628	189,023	171,334
Cortland				
Cottrell				
Chatham-Riverton	14,883	45,826	68,730	51,988
Davidson No. 1				
Davidson No. 2				
Chicagon				
Fogarty	7,949	32,560	77,356	51,071
Forbes				
Hiawatha	210,683	138,190	136,739	128,884
Homer				
Iron River	904,587			
James (Osana)	2,360	59,760	90,851	78,388
*Dober-Isabella	65,192			
Nanaimo	373,460	305		
Riverton (Dober and Isabella)	922,825	47,073	171,200	84,269
Rogers				
Selden	2,092			
Sheridan	116,299			
Tully				2,726
Virgil				
Wauseca				
Wickwire				
Youngs	151,141	70,094	154,150	98,399
Zimmerman		1,832	10,303	25,555
Total	3,877,202	630,745	1,152,076	1,001,960

*Riverton.

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

1911	1912	1913	1914	1915	1916	Total
3,290	....	24,286	113,733	41,378	....	267,107
66,502	100,736	130,631	29,206	10,078	110,965	1,788,711
....	....	....	....	45,171	72,275	117,446
....	....	23,259	5,539	39,615	140,961	209,374
22,272	33,422	....	23,826	15,413	38,470	269,137
....	....	....	....	....	....	4,211
165,660	306,914	295,841	279,379	479,083	448,631	2,674,813
....	17,499	26,823	15,316	....	....	59,638
....	....	....	....	45	75,089	75,134
58,054	135,298	107,604	19,455	[1]132,664	188,807	823,309
215	27,614	115,499	70,881	86,103	96,518	396,830
45,219	98,760	79,948	51,686	66,327	67,731	409,671
108,947	149,619	137,002	114,849	[2]155,411	100,640	766,468
67,616	84,074	124,568	15,329	27,718	89,506	577,747
....	....	69,435	77,960	[3]99,219	121,010	367,624
116,633	220,106	160,511	91,370	93,453	187,070	1,483,639
....	....	....	....	102,511	156,528	259,039
....	....	....	....	....	....	904,587
50,439	75,702	176,634	73,832	102,294	136,645	846,905
....	....	....	....	....	....	65,192
....	....	....	....	....	....	373,765
200,142	171,493	160,818	176,274	262,382	174,992	2,371,468
....	....	....	27,081	53,155	81,842	162,078
....	....	....	....	....	....	2,092
....	....	....	....	....	....	116,299
8,323	....	16,650	63,411	242,049	236,302	569,461
....	3,750	48,395	5,972	....	35,948	94,065
749	....	12,377	....	19,361	30,470	62,957
1,919	40,417	40,322	25,584	....	12,890	121,132
89,450	83,528	43,649	....	....	53,691	744,102
110,084	187,584	149,309	172,720	108,218	138,881	904,486
1,115,514	1,736,516	1,943,560	1,453,403	2,181,694	2,795,862	17,888,532

[1]Iron Trade Review reports 132,779 tons shipped 1915.
[2]Iron Trade Review reports 155,711 tons shipped 1915.
[3]Iron Trade Review reports 99,050 tons shipped 1915.
Total for Iron River district 1915, Iron Trade Review 2,182,934 tons.

SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS.)

	1903 and prior years.	1904	1905	1906	1907
Marquette	69,074,846	2,767,242	4,086,943	3,935,293	3,907,955
Gwinn	642,907	76,461	129,079	166,894	380,118
Menominee	31,563,402	1,712,800	2,741,169	2,953,131	2,498,784
Crystal Falls	8,093,686	917,969	1,174,366	1,395,910	1,631,484
Iron River	2,096,091	284,273	337,973	568,469	589,946
Gogebic	34,555,808	2,042,398	3,215,352	3,113,981	3,093,083
Metropolitan	164,323	4,737	....	....	13,913
Calumet	38,913	....	....	15,773	51,646
Total	146,229,876	7,805,880	11,684,432	12,149,451	12,166,929
	1908	1909	1910	1911	1912
Marquette	2,214,782	3,983,436	3,840,129	2,614,881	3,406,646
Gwinn	199,850	272,736	552,597	346,104	510,398
Menominee	1,254,110	1,991,108	1,674,447	1,421,840	1,538,746
Crystal Falls	629,602	1,425,261	1,206,592	1,254,135	1,304,739
Iron River	630,745	1,152,076	1,001,960	1,115,514	1,736,966
Gogebic	2,348,626	3,402,415	3,652,918	2,102,322	3,883,011
Metropolitan	9,123	24,933	26,462	33,758	12,468
Calumet	15,222	....	....	....	35,387
Total	7,302,060	12,251,965	11,955,105	8,898,554	12,428,361
	1913	1914	1915	1916	Total
Marquette	3,487,993	2,340,326	3,778,098	4,694,669	114,137,545
Gwinn	302,573	199,027	358,811	642,388	4,779,946
Menominee	1,680,620	1,156,452	1,355,289	1,871,747	55,423,645
Crystal Falls	1,172,948	535,457	1,241,187	1,491,421	23,474,757
Iron River	1,943,560	1,453,403	2,181,694	2,795,862	17,888,532
Gogebic	3,847,398	3,150,609	4,591,040	7,316,885	80,315,846
Metropolitan	9,251	....	....	....	298,868
Calumet	18,976	....	....	....	175,917
Total	12,463,319	8,835,274	13,506,119	18,812,972	296,495,056

SHIPMENTS OF IRON ORE FROM MICHIGAN RANGES BY COUNTIES.
(GROSS TONS.)

County.	1903 and prior years.	1904	1905	1906	1907
Gogebic	34,555,808	2,042,398	3,215,352	3,113,981	3,093,083
Iron	10,189,777	1,202,242	1,512,339	1,964,379	2,221,430
Dickinson	31,766,538	1,717,537	2,741,169	2,968,904	2,564,343
Marquette	68,962,760	2,817,195	4,175,605	4,097,111	4,154,288
Baraga	744,993	26,508	39,967	5,076	133,785
Total	146,229,876	7,805,880	11,684,432	12,149,451	12,166,929

County	1908	1909	1910	1911	1912
Gogebic	2,348,626	3,402,415	3,652,918	2,102,322	3,883,011
Iron	1,260,347	2,577,337	2,208,552	2,369,649	3,041,705
Dickinson	1,278,455	2,016,041	1,700,909	1,465,598	1,585,601
Marquette	2,305,366	3,888,055	4,236,311	2,871,116	3,864,101
Baraga	109,266	368,117	156,415	89,642	53,943
Total	7,302,060	12,251,965	11,955,105	8,898,327	12,428,361

County	1913	1914	1915	1916	Total
Gogebic	3,836,739	3,150,609	4,591,040	7,316,885	80,315,846
Iron	3,116,508	1,988,860	3,422,881	4,287,283	41,363,289
Dickinson	1,708,847	1,156,452	1,355,289	1,871,747	55,898,430
Marquette	3,753,023	2,494,029	4,018,294	5,297,050	116,910,747
Baraga	37,543	45,324	118,615	40,007	2,006,744
Total	12,452,660	8,835,274	13,506,119	18,812,972	296,495,056

AVERAGE NUMBER OF MEN EMPLOYED IN THE IRON MINES OF MICHIGAN IN 1916 BY COUNTIES.

	Gogebic	Iron	Dickinson	Baraga	Marquette
Total employed in producing mines = 17,544	6,496	4,275	2,364	73	4,336
Total in idle mines and explorations = 455	10	230	none	none	215
Total = 17,999*	6,506	4,505	2,364*	73	4,551*

*Indiana mine in Dickinson County not reported. Empire mine in Marquette County not reported.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN

Name of mine.	Location.				First shipment.	No. of men employed 1916.	Depth, 1916, Feet.
	County.	Section.	Twp.	Rge.			
Marquette Range:							
American and Boston	Marquette	32	48	28	1880	294	1,620
Breitung Hematite No. 1	Marquette	8	47	26	1903	140	960
Breitung Hematite No. 2	Marquette	8	47	26	......	90	640
Cambria	Marquette	35	48	27	1875	122	978
Champion	Marquette	31,32	48	29	1867	......	1984
Chase	Marquette	3	47	28	1913	......	351
Cliff Shaft	Marquette	9,10	47	27	1887	336	987
Empire	Marquette	19	47	26	1907	*	200
Gwinn	Marquette	28	45	25	1914	181	1,009
Hartford (Cambria No. 2)	Marquette	36	48	27	1889	......	......
Himrod (see Mary Charlotte)	Marquette	7	47	26	1914	......	640
Imperial	Baraga	25	48	31	1890	1	185
Isabella	Marquette	29,32	47	26	1915	151	702
Jackson	Marquette	1	47	27	1846	......	......
Lake and Moro	Marquette	10	47	27	1892	284	591
Lake Sally	Marquette	14	47	27	1915	8	......
Lake Superior (Hard Ore)	Marquette	9,10	47	27	1858	319	1,080
Lake Superior (Soft Ore)	Marquette	10	47	27	1858	7	820
Lake Angeline (Angeline)	Marquette	15	47	27	1864	26	615
Lloyd (see Morris)	Marquette	6	47	27	1911	......	808
Lucy (with Jackson)	Marquette	6,7	47	26	1878	......	......
Maas	Marquette	31	48	26	1907	220	1,100
Maitland (Volunteer)	Marquette	30	47	26	......	......	506
Mary Charlotte	Marquette	8	47	26	1903	275	640
Morris and Lloyd	Marquette	1	47	28	1912	291	860
Moro with Lake	Marquette	10	47	27	1881	......	......
Negaunee	Marquette	5,6	47	26	1887	358	1,086
Ohio	Baraga	22	48	31	1882	72	250
Portland	Baraga	26	48	31	1896	......	†
Queen Group	Marquette	5	47	26	1888	212	1,010
Republic	Marquette	7	46	29	1872	269	2,150
Richmond	Marquette	28	47	26	1896	85	†
Rolling Mill	Marquette	7	47	26	1872	86	786
Salisbury	Marquette	15	47	27	1872	123	941
Volunteer	Marquette	30	47	26	1871	93	506
Washington (Barron)	Marquette	11	47	29	1865	10	875
Swanzy District:							
Austin	Marquette	20	45	25	1907	53	364
Princeton	Marquette	18,20	45	25	1872	8	782
Stegmiller	Marquette	17	45	25	1909	59	300
Stephenson	Marquette	20	45	25	1907	236	562
Menominee Range:							
Aragon	Dickinson	8,9	39	29	1889	349	1,355
Chapin	Dickinson	25,30	40	31,30	1880	720	1,501
Cyclops & Norway (Penn Grip)	Dickinson	5	39	29	1878	......	355
East Vulcan (Penn Group)	Dickinson	10,11	39	29	1877	756	1,400
Indiana	Dickinson	27	40	30	1915	*	85
Loretto	Dickinson	7	39	28	1893	183	800
Millie (Hewitt)	Dickinson	31	40	34	1881	1	312
Munro	Dickinson	6	39	29	1903	40	170
Pewabic	Dickinson	32	40	30	1890	249	941
West Vulcan, Curry & Brier Hill	Dickinson	9,10	39	29	1879	......	1,770
Clifford and Traders	Dickinson	20	40	30	......	66	143

*Not reported.
†Undeveloped.

1916, WITH LOCATION, OWNERSHIP, ETC.

Number or name of level.	Operators.	Address of Home Office.
20th	American Boston Mining Co......	1300 Leader-News Building, Cleveland, Ohio.
9th	Breitung Hematite Mng. Co......	Marquette, Mich.
6th	Breitung Hematite Mng. Co......	Marquette, Mich.
5th	Republic Iron & Steel Co.........	Youngstown, Ohio.
33rd	Champion Iron Co..............	Wolvin Building, Duluth, Minnesota.
3rd	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
10th	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
2nd	Empire Iron Co.................	Rector Building, Chicago, Illinois.
8th	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
....	Republic Iron & Steel Co.........	Youngstown, Ohio.
6th	Mary Charlotte Mng. Co.........	Marquette, Mich.
4th	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
1st	Cascade Mining Co..............	Hibbing, Minn.
....	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
5th	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
....	Jones & Laughlin Ore Co.........	Pittsburg, Penn.
1080 L	Oliver Iron Mining Co...........	Wolvin Building, Duluth, Minn.
820 L	Oliver Iron Mining Co...........	Wolvin Building, Duluth, Minn.
9th	Pittsburg & Lake Angeline Iron Co.	Cleveland, Ohio.
3rd	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
....	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
3rd	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
5th	Volunteer Ore Co................	1400 Alworth Bld., Duluth, Minn.
6th	Mary Charlotte Mining Co.......	Marquette, Mich.
4th	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
....	Cleveland Cliffs Iron Co..........	Ishpeming, Mich.
9th	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
6th	Niagara Iron Mining Co.........	North Tonawanda, N. Y.
....	Niagara Iron Mining Co.........	North Tonawanda, N. Y.
1010 L	Oliver Iron Mining Co...........	Wolvin Bldg., Duluth, Minn.
2150 L	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
....	Richmond Iron Co..............	1300 Leader-News Bldg., Cleveland, Ohio.
8th	Jones & Laughlin Ore Co.........	3d Ave. & Try St., Pittsburg, Pa.
19th	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
5th	Volunteer Ore Co................	1400 Alworth Bldg., Duluth, Minn.
10th	Washington Iron Co.............	Marquette, Mich.
6th	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
6th	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
2nd	American Mining Co.............	Western Reserve Building, Cleveland, Ohio.
5th	Cleveland Cliffs Iron Co.........	Ishpeming, Mich.
14th	National Tube Works Co.........	Frick Bldg., Pittsburg, Pa.
17th	Chapin Mining Co..............	Wolvin Bldg., Duluth, Minn.
....	Penn Iron Mining Co............	1703 Morris Bldg., Philadelphia, Pa.
....	Penn Iron Mining Co............	1703 Morris Bldg., Philadelphia, Pa.
1st	Thomas Furnace Co.............	Milwaukee, Wis.
8th	Loretto Iron Co.................	1400 Fulton St., Chicago, Ill.
3rd	Dessau Mining Co..............	Care B. J. Clergue, Montreal, Que.
2nd	Munro Iron Mining Co..........	55 Erie Co. Bank Bldg., Buffalo, N. Y.
8th	Pewabic Co.....................	910 Wells Bldg., Milwaukee, Wisconsin.
18th	Penn Iron Mining Co............	1703 Morris Bldg., Philadelphia, Pa.
1st	Antoine Ore Company...........	Republic Building, Youngstown, Ohio.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN,

Name of mine.	Location. County.	Section.	Twp.	Rge.	First shipment.	No. of men employed 1916.	Depth. 1916, Feet.
CRYSTAL FALLS DISTRICT:							
Amasa Porter	Iron	22,33	44	33	1916	85	400
Bristol	Iron	19	43	32	1892	200	1,060
Carpenter	Iron	31	43	32	1914	246	330
Dunn-Richards	Iron	1	42	33	1887	98	1,623
Genesee (with Tobin)	Iron	29,30,31	43	32	1902	......	......
Great Western	Iron	21	43	32	1882	1	1,257
Hemlock	Iron	4	44	33	1891	5	1,015
Judson	Iron	13	42	33	1914	158	300
Michigan (with Hemlock)	Iron	9	44	33	1893	......	1,015
Odgers	Iron	30	43	32	1916	125	150
Ravenna	Iron	19	43	32	1911	49	350
Tobin	Iron	30	43	32	1901	254	1,335
Warner	Iron	9	44	33	1915	59	740
IRON RIVER DISTRICT:							
Baker-Tully	Iron	31	43	34	1909	285	548
Balkan	Iron	13	42	33	1915	137	232
Baltic	Iron	7	42	34	1901	242	553
Bates	Iron	19	43	34	1915	96	850
Bengal	Iron	36	43	35	1913	186	280
Berkshire	Iron	6	42	34	1908	70	365
Caspian	Iron	1	42	35	1903	363	292
Chatham-Riverton	Iron	35	43	35	1907	178	925
Chicagon	Iron	26	43	34	1911	109	712
Cortland	Iron	34	43	35	1912	......	405
Cottrell	Iron	1	42	35	1915	56	265
Davidson No. 1	Iron	23	43	35	1912	70	450
Davidson No. 2	Iron	14	43	35	1912	78	240
Fogarty (see Baltic)	Iron	1	42	35	1907	......	365
Forbes	Iron	14	43	35	1913	117	275
Hiawatha	Iron	35	43	35	1893	101	1,029
Homer	Iron	22,23	43	35	1915	154	350
Osana (James)	Iron	23	43	35	1907	117	428
Dober Isabella (Riverton)	Iron	1,35.36	42,43	35	1898	96	1,000
Rogers	Iron	29	43	34	1914	139	330
Tully (see Baker)	Iron	36	43	35	1910	......	438
Virgil	Iron	24	43	35	1912	46	273
Wauseca	Iron	23	43	35	1910	48	398
Wickwire	Iron	35	43	35	1911	23	313
Youngs	Iron	12	42	35	1905	106	575
Zimmerman	Iron	7	42	34	1908	178	350
GOGEBIC RANGE:							
Anvil	Gogebic	14	47	46	1887	4	1,663
Asteroid	Gogebic	13	47	46	1906	136	1,130
Ashland	Gogebic	22	47	47	1885	150	1,900
Brotherton	Gogebic	9	47	45	1886	103	1,157
Castile	Gogebic	10	47	45	1906	155	1,770
Colby and Ironton	Gogebic	16	47	46	1884	760	1,314
Davis, Geneva, Royal, Puritan	Gogebic	17,18 19,20	46	47	1886	398	1,754
Eureka	Gogebic	13	47	46	1890	240	1,950
Ironton (see Colby)	Gogebic	17	47	46	1886	......	......
Keweenaw	Gogebic	11	47	46	1914	116	1,663
Mikado	Gogebic	18	47	45	1895	65	1,131
Newport and Bonnie	Gogebic	24	47	47	1886	880	2,168
Norrie-Aurora Group	Gogebic	22,23	47	47	1884	1,845	1,676
Palms	Gogebic	14	47	46	1912	464	1,663
Plymouth	Gogebic	18	47	45	1916	161	*
Puritan (see Davis)	Gogebic	17	47	46	1886	......	......
Sunday Lake	Gogebic	10	47	45	1885	210	1,391
Tilden	Gogebic	15	47	46	1891	241	1,526
Wakefield	Gogebic	16,17	47	45	1913	452	*
Yale	Gogebic	16	47	46	1901	116	1,757

*Open pit.

1916, WITH LOCATION, OWNERSHIP, ETC.—*Concluded.*

Number or name of level.	Operators.	Address of Home Office.
11th	Bristol Mining Co.	Wade Building, Cleveland, Ohio.
4th	Nevada Mining Co.	Duluth, Minnesota.
1st	Hollister Mining Co.	1300 Leader-News Bldg., Cleveland, Ohio.
13th	Corrigan, McKinney Co.	Wickliffe, Ohio.
....	Corrigan, McKinney Co.	Wickliffe, Ohio.
16th	Corrigan, McKinney Co.	Wickliffe, Ohio.
14th	Hemlock River Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
3rd	Judson Mining Co.	First National Bank Bldg., Chicago, Illinois.
....	Hemlock River Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
1st	Hudson Iron Mining Co.	Wickliffe, Ohio.
2nd	Hollister Mining Co.	1300 Leader News Bldg., Cleveland, Ohio.
13th	Corrigan, McKinney Co.	Wickliffe, Ohio.
7th	Hemlock River Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
4th	Corrigan, McKinney Co.	Wickliffe, Ohio.
1st	Balkan Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
7th	Verona Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
850 L	Bates Iron Co.	New York City, 25 Broad St.
2nd	Verona Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
4th	Brule Mining Co.	76 Wade Building, Cleveland, Ohio.
3rd	Verona Mining Co.	Cleveland, Ohio, Western Reserve Bldg.
9th	Brule Mining Co.	76 Wade Bldg., Cleveland, Ohio.
7th	Munro Mining Co.	55 Erie Co. Bank Bldg., Buffalo, N. Y.
4th	Wickwire Mining Co.	Buffalo, N. Y.
3rd	Oliver Iron Mining Co.	Duluth, Minn., Wolvin Bldg.
450 L	Davidson Ore Mining Co.	403 White Bldg., Buffalo, N. Y.
2nd	Davidson Ore Mining Co.	403 White Bldg., Buffalo, N. Y.
4th	Verona Mining Co.	Western Reserve Bldg., Cleveland, Ohio.
2nd	Jones & Laughlin Ore Co.	3d Ave. & Try St., Pittsburg, Pa.
9th	Munro Mining Co.	55 Erie Co. Bank Bldg., Buffalo, N. Y.
2nd	Buffalo Iron Mining Co.	Buffalo, N. Y., Station B.
4th	Mineral Mining Co.	910 Wells Bldg., Milwaukee, Wis.
10th	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
1st	Munro Iron Mining Co.	55 Erie Co., Bank Bldg., Buffalo, N. Y.
4th	Corrigan, McKinney Co.	Wickliffe, Ohio.
2nd	Wickwire Mining Co.	Buffalo, N. Y.
4th	Mineral Mining Co.	910 Wells Bldg., Milwaukee, Wis.
4th	Wickwire Mining Co.	Buffalo, N. Y.
5th	Huron Iron Co.	Iron River, Mich.
4th	Spring Valley Iron Co.	Wellston, Ohio, Jackson Co.
11th	Newport Mining Co.	First National Bank Bldg., Milwaukee, Wis.
12th	Castile Mining Co.	76 Wade Bldg., Cleveland, Ohio.
25th	Hayes Mining Co.	808 1st National Bank Bldg., San Jose, Cal.
21st	Brotherton Iron Mining Co.	Western Reserve Bldg., Cleveland, Ohio.
17th	Castile Mining Co.	76 Wade Bldg., Cleveland, Ohio.
19th	Corrigan, McKinney Co.	Wickliffe, Ohio.
18th	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
19th	Castile Mining Co.	76 Wade Bldg., Cleveland, Ohio.
....	Corrigan, McKinney Co.	Wickliffe, Ohio.
11th	Newport Mining Co.	First National Bank Bldg., Milwaukee, Wis.
16th	Verona Mining Co.	Western Reserve Bldg., Cleveland, Ohio.
19th	Newport Mining Co.	First National Bank Bldg., Milwaukee, Wis.
23rd	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
11th	Dunn Iron Mining Co.	First National Bank Bldg., Milwaukee, Wis.
....	Coates & Tweed	Duluth, Minnesota.
....	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
23rd	Sunday Lake Iron Co.	Western Reserve Bldg., Cleveland, Ohio.
23rd	Oliver Iron Mining Co.	Wolvin Bldg., Duluth, Minn.
....	Wakefield Iron Co.	1300 Leader-News Bldg., Cleveland, Ohio.
1757 L	Lake Superior Iron & Chemical Co.	Penobscot Bldg., Detroit, Mich., F. W. Blair, Receiver.

IRON ORE RESERVES OF MICHIGAN.

Range.	1911 [1]		1913 [2]		1914 [3]	
	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.
Gogebic county	18,296,721	13,308,279	23,813,191	7,754,388	23,765,158	21,113,192
Iron county: (Iron River District) (Crystal Falls District)	7,934,687	25,689,155	13,249,683	47,536,233	13,337,913	45,045,227
Menominee: (Dickinson county)	9,082,750	2,567,700	9,682,994	3,100,458	11,062,700	2,129,950
State	71,542,900	98,038,202	81,437,902	109,920,354	81,261,238	116,208,087
Total	169,581,102		191,358,256†		197,469,325*	

*Of date Jan. 1, 1914 in addition to which there was in stock 4,954,830 tons of ore, making a grand total of 202, 424,155 tons.
†Of date Jan. 1, 1913 in addition to which there was in stock 4,366,349 tons of ore, making a grand total of 195,724,605 tons.
[1]Estimated by C. K. Leith for Board of State Tax Commissioners.
[2]Estimate by C. K. Leith and R. C. Allen for Board of State Tax Commissioners.
[3]Estimate by R. C. Allen and O. R. Hamilton for Board of State Tax Commissioners.

IRON ORE RESERVES OF MICHIGAN.—*Concluded.*

Range.	1915 [a]		1916 [a]		1917 [a]	
	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.
Gogebic county	33,764,457	12,838,990	32,181,415	25,743,175	29,458,730	16,289,986
Iron county: (Iron River District) (Crystal Falls District)	19,258,369	42,961,778	17,332,239	40,935,494	15,274,255	42,217,450
Menominee: (Dickinson county)	10,134,241	1,701,540	8,035,306	1,671,055	7,506,771	2,710,080
Marquette: (Baraga county) (Marquette county)	28,629,708	50,235,260	30,655,677	49,239,115	47,509,118	46,130,241
State	91,786,775	107,737,568	88,204,637	117,588,839	99,748,874	107,347,757
Total	199,524,343‡		205,793,476**		207,096,631***	

*Of date Jan. 1, 1914 in addition to which there was in stock 4,954,830 tons of ore, making a grand total of 202,424,155 tons.
‡Of date Jan. 1, 1915 in addition to which there was in stock 6,596,195 tons of ore, making a grand total of 206,120,538 tons.
**Of date Jan. 1, 1916 in addition to which there was in stock 5,608,465 tons of ore, making a grand total of 211,401,941 tons.
***Of date Jan. 1, 1917 in addition to which there was in stock 5,132,343 tons of ore, making a grand total of 212,228,974 tons.
[a]Estimated by R. C. Allen and O. R. Hamilton for Board of State Tax Commissioners.

APPRAISED VALUE OF MICHIGAN IRON MINES.[1]

Range.	Previous appraisals.					
	1911	1912	1913	1914	1915	1916
Gogebic	$28,338,100	$27,226,300	$25,849,873	$34,667,028	$34,377,792	$34,210,394
Iron county:						
(Iron River District) (Crystal Falls District)	15,018,475	15,359,664	20,978,709	21,275,945	20,856,919	20,977,257
Menominee:						
Dickinson county	7,427,500	7,240,625	6,641,925	6,413,003	5,906,443	5,758,461
Marquette:						
Baraga county						
Marquette county	34,745,000	*31,270,500	29,063,714	29,216,139	28,616,453	29,791,496
State	$85,529,075	$81,097,089	$82,534,221	$91,572,115	$89,757,607	$90,737,608

*Ten per cent cut from 1911 assessment (approximate figure).
[1]By Board of State Tax Commissioners.

APPRAISED VALUE OF MICHIGAN IRON MINES.[1]—*Concluded.*

	1917 appraisal.		Combined value of mine and ore in stock.	Total tonnage in mine and in stock Jan. 1, 1916.	Assessed value per ton.
	Mine.	Ore in stock.			
Gogebic	$28,420,805	$5,867,345	$34,288,150	$46,710,999	.73405
Iron county:					
(Iron River District) (Crystal Falls District)	16,607,727	5,385,241	21,992,968	59,117,778	.37201
Menominee:					
Dickinson county	4,161,994	1,654,873	5,816,867	10,591,146	.54921
Marquette:					
Baraga county				95,809,051	
Marquette county	23,806,834	6,286,089	30,092,923		.31409
State	$72,997,360	$19,193,548	$92,190,908	$212,228,974	.43439

[1]By Board of State Tax Commissioners.

VALUE OF MICHIGAN IRON ORE SHIPMENTS 1916 FROM REPORT OF APPRAISER OF MINES TO BOARD OF STATE TAX COMMISSIONERS 1916.[1]

Range.	Gross receipts.	*"Beyond the Mine" charges.	Net receipts f. o. b. at the mine.	Shipment. Tons. 1916.	Value per ton f. o. b. mine 1916.	Value per ton f. o. b. mine 1915.
Gogebic—Gogebic county	$27,337,652 08	$7,554,431 09	$19,783,220 99	7,321,273	$2.70215	$2.24461
Iron River / Crystal Falls } Iron county	12,375,501 47	3,628,949 44	8,746,552 03	4,266,827	2.04989	1.85211
Menominee—Dickinson county	6,374,944 57	1,595,035 70	4,779,908 87	1,827,585	2.61542	2.06583
Marquette { Marquette county / Baraga county }	16,583,255 69	4,008,607 10	12,574,648 59	5,210,366	2.41339	1.88601
State of Michigan	$62,671,353 81	$16,787,023 33	$45,884,330 48	$18,626,051	$2.46344	$2.02060

*Includes: 1. Rail freight.
2. Boat freight.
3. Cargo insurance.
4. Lower lake analyses.
5. Selling commissions.

[1]From report of Appraiser of Mines to Board of State Tax Commissioners 1917.

1916 U. S. Production = 75,167,672 gross tons. Shipments 77,870,553 gross tons.
Valued at $181,902,277 or average price of $2.34 per ton.

**Of which the Lake Superior District produced 63,960,956 tons, or 85 per cent of the total.
Tonnage mined during 1916 is given by U. S. G. S. as 75,167,672 gross tons

of which Minnesota	mined	44,585,422 tons.
Michigan	mined	18,071,016 tons.
Alabama	mined	6,747,901 tons.
Wisconsin	mined	1,304,518 tons.
New York	mined	1,342,507 tons.
All other states	mined	3,116,308 tons.
Total......		75,167,672 tons.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MARQUETTE RANGE, MARQUETTE COUNTY, MICH.

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.08148	$0.11454	$0.06125	$0.05057	$0.05898	$0.08927
	b	.07846	.11416	.06121	.04739	.05768	.08603
2. Fire insurance	a	.00075	.00044	.00564	.00397	.00328	.00351
	b	.00037	.00042	.00544	.00378	.00321	.00338
3. Employers liability insurance	a	....	....	.00441	.00339	.00510	.01152
	b	....	....	.00439	.00339	.00509	.01119
4. Taxes	a	.05630	.06870	.08099	.08026	.07564	.15193
	b	.05567	.06863	.07922	.07867	.07471	.14934
5. Depreciation	a	....	....	.09942	.09080	.05299	.09964
	b	....	....	.09942	.09080	.05207	.08920
6. Mining	a	1.33839	1.40609	1.52434	1.50437	1.38899	1.50322
	b	1.32326	1.40609	1.51431	1.50317	1.37501	1.48929
7. Exploration and development	a	.06841	.09228	.09939	.07166	.06095	.08208
	b	.05708	.08664	.09939	.06360	.05389	.07039
8. Construction	a	.08579	.10932	.02212	.06506	.08351	.07106
	b	.06954	.10932	.02212	.05813	.06447	.07061
9. Total cost at mine	a	1.63112	1.79137	1.89756	1.87008	1.72944	2.01223
	b	1.58438	1.78526	1.88550	1.84893	1.68613	1.96943
Beyond the Mine Cost.							
10. Rail freight	a	.26842	.27659	.29435	.29444	.29841	.23228
	b	.26842	.27659	.29425	.29427	.29841	.22936
11. Boat freight	a	.49696	.48986	.44747	.46945	.48127	.35463
	b	.49696	.48986	.44747	.46945	.48127	.35463
12. Cargo insurance	a	.00140	.00192	.00021	.00085	.00088	.00113
	b	.00140	.00192	.00021	.00085	.00088	.00113
13. Analysis at lower lake ports	a	.00047	.00031	.00022	.00069	.00099	.00180
	b	.00047	.00031	.00022	.00069	.00099	.00180
14. Selling commissions	a	.00915	.01198	.01629	.01873	.01852	.02815
	b	.00915	.01198	.01629	.01873	.01852	.02774
15. Total "Beyond the Mine" cost	a	.77640	.78066	.75864	.78419	.80007	.61797
	b	.77640	.78066	.75854	.78402	.80007	.61466

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MARQUETTE RANGE, MARQUETTE COUNTY, MICH.

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Beyond the mine cost.—*Con.*							
16. Total cost of delivery	a	$2.40752	$2.57203	$2.65620	$2.65427	$2.52951	$2.63020
	b	2.36078	2.56592	2.64404	2.63295	2.48620	2.58409
17. Royalties	a	.12239	.13238	.21741	.18385	.21752	.24763
	b	.12239	.13238	.20704	.17744	.20591	.24036
18. Total cost of delivery to operator	a	2.52991	2.70441	2.87361	2.83812	2.74753	2.87783
	b	2.48317	2.69830	2.85108	2.81039	2.69211	2.82445
Profit and Loss.							
19. Receipts from sale of ore		3.37320	3.77856	3.80000	3.51487	3.70991	3.59091
20. Profit or loss to operator	a	.84329	1.07415	.92369	.67675	.96288	.71308
	b	.89003	1.08027	.94892	.70448	1.01780	.76646
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.96568	1.20653	1.24052	.95140	1.23339	1.06035
	b	1.01242	1.21265	1.25538	.97272	1.27578	1.09602
22. Assessed valuation per ton by Board of State Tax Commissioners		....	....	....	....	....	.37480

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 inclusive and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MARQUETTE RANGE, MARQUETTE COUNTY, MICH.—*Concluded.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.09194	$0.06932	$0.07754	$0.05827	$0.06977	....
	b	.08885	.06680	.07091	.05686	.06857	....
2. Fire insurance	a	.00388	.00357	.00435	.00378	.00292	....
	b	.00370	.00341	.00389	.0343	.00272	....
3. Employer's liability insurance	a	.01135	.01850	.01869	.02069	.01841	....
	b	.01135	.01840	.01824	.02069	.01827	....
4. Taxes	a	.14140	.12160	.12630	.13616	.11330	....
	b	.13837	.11820	.11917	.13074	.10877	....
5. Depreciation	a	.08597	.06817	.14911	.11265	.10585	....
	b	.08570	.06803	.13785	.11074	.10473	....
6. Mining	a	1.46207	1.45000	1.31975	1.13464	1.26168	....
	b	1.45260	1.44664	1.30840	1.13367	1.26014	....
7. Exploration and development	a	.07939	.06080	.07550	.06522	.03823	....
	b	.06985	.05170	.03729	.06522	.03823	....
8. Construction	a	.07912	.08205	.15827	.05274	.17699	....
	b	.06096	.04476	.12717	.05266	.15086	....
9. Total cost at mine	a	1.95512	1.87401	1.92951	1.61115	1.68130	....
	b	1.91138	1.81794	1.82292	1.57401	1.64756	....
Beyond the Mine Cost.							
10. Rail freight	a	.26284	.30700	.28232	.29318	.30783	....
	b	.25878	.30367	.27765	.29318	.30783	....
11. Boat freight	a	.29943	.38732	.31371	.32504	.43619	....
	b	.29838	.38265	.30677	.32504	.43619	....
12. Cargo insurance	a	.00191	.00117	.00091	.00127	.00176	....
	b	.00191	.00116	.00091	.00127	.00176	....
13. Analysis at lower lake ports	a	.00094	.00465	.00411	.00375	.00432	....
	b	.00094	.00463	.00411	.00375	.00431	....
14. Selling commissions	a	.01477	.02128	.01749	.01375	.01923	....
	b	.01477	.02040	.01597	.01373	.01911	....
15. Total "Beyond the Mine" cost	a	.57987	.72142	.61854	.63699	.76933	....
	b	.57478	.71251	.60541	.63697	.76920	....

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MARQUETTE RANGE, MARQUETTE COUNTY, MICH.—*Concluded.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.53501	$2.59543	$2.54805	$2.24814	$2.45063	....
	b	2.48616	2.53045	2.42833	2.21098	2.41676	....
17. Royalties	a	.19117	.19221	.21773	.18120	.19079	....
	b	.18478	.18469	.21772	.17913	.18575	....
18. Total cost of delivery to operator	a	2.72618	2.78764	2.76578	2.42934	2.64142	....
	b	2.67094	2.71514	2.64555	2.39011	2.60251	....
Profit and Loss.							
19. Receipts from sale of ore		2.90551	3.15906	2.82446	2.52302	3.17105	....
20. Profit or loss to operator	a	.17933	.37142	.05868	.09368	.52963	....
	b	.23457	.44392	.17891	.13291	.56854	....
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.45647	.63180	.42552	.38753	.82627	....
	b	.50505	.69664	.53398	.42278	.85902	....
22. Assessed valuation per ton by Board of State Tax Commissioners		....	.34464	.35034	.34913	.36090	$0.31409

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 inclusive and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE GOGEBIC RANGE, GOGEBIC COUNTY, MICH.

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Cost of Mining.							
1. General office expense	a	$0.07006	$0.06827	$0.07218	$0.06973	$0.05213	$0.08225
	b	.06908	.06734	.07092	.06901	.05119	.08225
2. Fire insurance	a	.00226	.00256	.00431	.00378	.00415	.00708
	b	.00218	.00245	.00419	.00374	.00413	.00708
3. Employers' liability insurance	a	....	....	.00379	.00495	.00664	.02721
	b	....	....	.00379	.00495	.00664	.02721
4. Taxes	a	.05509	.05834	.06429	.07432	.07565	.19711
	b	.05486	.05809	.06389	.07387	.07522	.19711
5. Depreciation	a	.00648	.00898	.12199	.14554	.12335	.15555
	b	.00648	.00898	.12199	.14554	.12335	.15555
6. Mining	a	1.22206	1.37212	1.46021	1.38712	1.32950	1.43033
	b	1.21186	1.35435	1.45340	1.36994	1.32950	1.43033
7. Exploration and development	a	.08821	.12328	.08133	.12984	.14909	.20058
	b	.08821	.12328	.08133	.09671	.14909	.20058
8. Construction	a	.20230	.22745	.24725	.19922	.08334	.12028
	b	.20230	.22745	.24725	.15107	.08334	.12028
9. Total cost at mine	a	1.64646	1.86100	2.05535	2.01451	1.82385	2.22039
	b	1.63497	1.84194	2.04676	1.91483	1.82246	2.22039
Beyond the Mine Cost							
10. Rail freight	a	.39625	.39142	.39280	.39047	.39285	.37326
	b	.39625	.39142	.39280	.39047	.39285	.37326
11. Boat freight	a	.73723	.73122	.64708	.63825	.70098	.48302
	b	.73733	.73122	.64708	.63825	.70098	.48302
12. Cargo insurance	a	....	....	....	.00240	.00319	.00290
	b	....	....	....	.00240	.00319	.00290
13. Analysis at lower lake ports	a	....	....	....	.00373	.00210	.00138
	b	....	....	....	.00373	.00210	.00138
14. Selling commissions	a	.03915	.03933	.04572	.05470	.04795	.03548
	b	.03915	.03933	.04572	.05470	.04795	.03548
15. Total "Beyond the Mine" cost	a	1.17263	1.16197	1.08560	1.08955	1.14707	.89604
	b	1.17263	1.16197	1.08560	1.08955	1.14707	.89604

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE GOGEBIC RANGE, GOGEBIC COUNTY, MICH.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.81909	$3.02297	$3.14095	$3.10406	$2.97092	$3.11643
	b	2.80760	3.00391	3.13236	3.00438	2.96953	3.11643
17. Royalties	a	.36805	.43373	.43762	.45323	.42650	.32388
	b	.36788	.43357	.43741	.43089	.42568	.32277
18. Total cost of delivery to operator	a	3.18714	3.45670	3.57857	3.55729	3.39742	3.44031
	b	3.17548	3.43740	3.56977	3.43527	3.39521	3.43920
Profit and Loss.							
19. Receipts from sale of ore		4.05982	4.73564	3.99683	4.07636	4.69212	3.87255
20. Profit or loss to operator	a	.87268	1.27893	.41826	.51907	1.29470	.43224
	b	.88433	1.29815	.42706	.64109	1.29691	.43335
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	1.24721	1.72164	.97787	1.11784	1.84455	.91167
	b	1.25869	1.74070	.98646	1.21752	1.84594	.91167
22. Assessed valuation per ton by Board of State Tax Commissioners							.89663

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE GOGEBIC RANGE, GOGEBIC COUNTY, MICH.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.06157	$0.05763	$0.06841	$0.05757	$0.07140	....
	b	.06157	.05760	.06837	.05757	.07138	....
2. Fire insurance	a	.00593	.00526	.00517	.00514	.00345	....
	b	.00593	.00526	.00506	.00514	.00343	....
3. Employer's liability insurance	a	.01913	.02207	.02667	.01998	.01898	....
	b	.01913	.02207	.02632	.01998	.01893	....
4. Taxes	a	.13478	.12522	.14182	.16451	.11574	....
	b	.13478	.12212	.14122	.16340	.11412	....
5. Depreciation	a	.11307	.12644	.09945	.22294	.14387	....
	b	.11307	.12594	.09871	.22294	.14381	....
6. Mining	a	1.19161	1.37673	1.18169	1.00309	1.13900	....
	b	1.19161	1.37673	1.17605	1.00294	1.13580	....
7. Exploration and development	a	.12864	.18028	.23965	.16489	.14048	....
	b	.12864	.17977	.23377	.16489	.13996	....
8. Construction	a	.04681	.24327	.18114	.13189	.12036	....
	b	.04681	.18736	.18082	.13189	.10196	....
9. Total cost at mine	a	1.70154	2.13690	1.94400	1.77001	1.60941	....
	b	1.70154	2.07685	1.93032	1.76875	1.58558	....
Beyond the Mine Cost.							
10. Rail freight	a	.38032	.44526	.40792	.40970	.43369	....
	b	.38032	.44520	.40762	.40970	.43369	....
11. Boat freight	a	.46717	.55204	.40087	.43081	.54064	....
	b	.46717	.55200	.40054	.43081	.54064	....
12. Cargo insurance	a	.00075	.00132	.00097	.00136	.00153	....
	b	.00075	.00132	.00097	.00136	.00153	....
13. Analysis at lower lake ports	a	.00222	.00248	.00288	.00289	.00336	....
	b	.00222	.00248	.00287	.00289	.00336	....
14. Selling commissions	a	.04801	.05374	.04889	.04929	.05261	....
	b	.04801	.05374	.04883	.04929	.05261	....
15. Total "Beyond the Mine" cost	a	.89847	1.05484	.86153	.89405	1.03183	....
	b	.89847	1.05477	.86083	.89405	1.03183	....

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE GOGEBIC RANGE, GOGEBIC COUNTY, MICHIGAN.—*Concluded.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operator.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.60001	$3.19174	$2.80553	$2.66406	$2.64124	....
	b	2.60001	3.13162	2.79115	2.66280	2.61741	....
17. Royalties	a	.26506	.30459	.31961	.29208	.32184	....
	b	.26445	.30275	.31882	.29154	.32067	....
18. Total cost of delivery to operator	a	2.86507	3.49633	3.12514	2.95614	2.96308	....
	b	2.86446	3.43437	3.10997	2.95434	2.93808	....
Profit and Loss.							
19. Receipts from sale of ore		3.30027	4.11367	3.32900	3.13869	3.73400	....
20. Profit or loss to operator	a	.43520	.61734	.20386	.18255	.77092	....
	b	.43581	.67930	.21903	.18435	.79592	....
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.81333	1.04837	.62292	.69757	1.23663	....
	b	.81333	1.10799	.63656	.69883	1.26040	....
22. Assessed valuation per ton by Board of State Tax Commissioners		....	.81887	.75715	.71260	.74478	$0.73405

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 and item 19 on tons shipped

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MENOMINEE RANGE, DICKINSON COUNTY, MICH.

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

			1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
	Cost of Mining.							
1.	General office expenses	a	$0.06131	$0.07640	$0.06687	$0.04570	$0.04250	$0.06026
		b	.06115	.07604	.06655	.04570	.04250	.05975
2.	Fire insurance	a	.00102	.00121	.00768	.00551	.00531	.00701
		b	.00098	.00114	.00758	.00551	.00531	.00701
3.	Employers liability insurance	a	....	....	.00341	.00143	.00605	.00334
		b	....	....	.00341	.00143	.00605	.00333
4.	Taxes	a	.04875	.06366	.11040	.10260	.10141	.15691
		b	.04844	.06331	.10967	.10260	.10141	.15565
5.	Depreciation	a	.00528	.00691	.16494	.14697	.14071	.12837
		b	.00528	.00691	.16123	.14697	.14071	.12818
6.	Mining	a	.98118	1.21721	1.20207	1.21584	1.26711	1.34760
		b	.98118	1.21721	1.20110	1.21584	1.26711	1.34636
7.	Exploration and development	a	.07647	.08296	.13769	.09243	.13863	.16300
		b	.07647	.08296	.13769	.09243	.13863	.16300
8.	Construction	a	.14287	.16885	.19086	.10095	.07037	.05983
		b	.13598	.16885	.19086	.10095	.07037	.05983
9.	Total cost at mine	a	1.31688	1.61720	1.88392	1.71143	1.77209	1.92632
		b	1.30948	1.61642	1.87809	1.71143	1.77209	1.92290
	"Beyond the Mine" Cost.							
10.	Rail freight	a	.32025	.31908	.30214	.32006	.30832	.31708
		b	.32025	.31908	.29914	.32006	.30832	.31544
11.	Boat freight	a	.34010	.33683	.37593	.37786	.39260	.33087
		b	.34010	.33683	.37445	.37786	.39260	.32815
12.	Cargo insurance	a	.00081	.00063	....	.00207	.00205	.00190
		b	.00081	.00063	....	.00207	.00205	.00190
13.	Analysis at lower lake ports	a	....	....	....	....	....	.00010
		b	....	....	....	....	....	.00010
14.	Selling commissions	a	.01403	.01336	.00920	.01645	.02251	.02215
		b	.01403	.01336	.00835	.01645	.02251	.02159
15.	Total "Beyond the Mine" cost	a	.71259	.71345	.70049	.76037	.80337	.68144
		b	.71259	.71345	.69516	.76037	.80337	.67652
	Unclassified		.03740	.04355	.01322	.04393	.07789	.00934

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MENOMINEE RANGE, DICKINSON COUNTY, MICH.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.02947	$2.33065	$2.58441	$2.47180	$2.57546	$2.60776
	b	2.02207	2.32987	2.57325	2.47180	2.57546	2.59942
17. Royalties	a	.22039	.28258	.23856	.25298	.30194	.24478
	b	.22039	.28258	.23856	.25298	.30194	.24478
18. Total cost of delivery to operator	a	2.24986	2.61323	2.82297	2.72478	2.87740	2.85254
	b	2.24246	2.61245	2.81181	2.72478	2.87740	2.84420
Profit and Loss.							
19. Receipts from sale of ore		3.13222	3.89632	2.93813	3.32263	3.49099	2.79390
20. Profit or loss to operator	a	.88236	1.28309	.11516	.59785	.61359	.05864
	b	.88975	1.28386	.12632	.59785	.61359	.05030
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	1.10803	1.57258	.51866	.99780	1.05624	.31551
	b	1.11542	1.57335	.52611	.99780	1.05624	.32266
22. Assessed valuation per ton by Board of State Tax Commissioners		....	....	....	....	....	.63752

a. Total of all operations.
b. Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 inclusive and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MENOMINEE RANGE, DICKINSON, COUNTY, MICH.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.06289	$0.04758	$0.06062	$0.06662	$0.05793	....
	b	.06084	.04667	.05911	.06192	.05687	....
2. Fire insurance	a	.00749	.00595	.00763	.00714	.00577	....
	b	.00684	.00571	.00732	.00682	.00569	....
3. Employers liability insurance	a	.01080	.01826	.01805	.01670	.01807	....
	b	.01074	.01823	.01801	.01670	.01807	....
4. Taxes	a	.18124	.16429	.17651	.17430	.11639	....
	b	.17778	.16248	.17534	.16985	.11474	....
5. Depreciation	a	.15657	.14460	.12758	.14988	.16714	....
	b	.14465	.13500	.12758	.13211	.16071	....
6. Mining	a	1.54642	1.42418	1.56567	1.55066	1.74539	....
	b	1.54135	1.42176	1.56472	1.54777	1.74464	....
7. Exploration and development	a	.16610	.14462	.15022	.10856	.01939	....
	b	.16598	.14462	.14617	.10856	.01939	....
8. Construction	a	.07908	.15735	.13618	.06791	.03167	....
	b	.07908	.15735	.13618	.06971	.03167	....
9. Total cost at mine	a	2.21059	2.10683	2.24246	2.14317	1.99461	....
	b	2.18726	2.09182	2.23443	2.11344	1.99107	....
"Beyond the Mine" Cost.							
10. Rail freight	a	.28654	.33679	.31258	.42976	.43243	....
	b	.27718	.33176	.31258	.42968	.43243	....
11. Boat freight	a	.23712	.29486	.25476	.31703	.40788	....
	b	.23061	.28994	.25476	.31703	.40788	....
12. Cargo insurance	a	.00038	.00048	.00076	.00068	.00084	....
	b	.00036	.00047	.00076	.00068	.00084	....
13. Analysis at lower lake ports	a	.00010	.00093	.00110	.00207	.00227	....
	b	....	.00089	.00110	.00207	.00227	....
14. Selling commissions	a	.01117	.01677	.01165	.02063	.02930	....
	b	.00949	.01654	.01158	.02014	.02905	....
15. Total "Beyond the Mine" cost	a	.58939	.72872	.61438	.77017	.87272	....
	b	.57172	.71899	.61431	.76960	.87242	....
Unclassified		.05408	.07939	.03353	....	....	....

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE MENOMINEE RANGE, DICKINSON COUNTY, MICH.—*Concluded.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.79998	$2.83555	$2.85684	$2.91334	$2.86733	....
	b	2.75808	2.81081	2.84774	2.88304	2.86354	....
17. Royalties	a	.19541	.21612	.18070	.19852	.24707	....
	b	.19313	.21406	.17810	.18853	.24513	....
18. Total cost of delivery to operator	a	2.99539	3.05167	3.03754	3.11186	3.11440	....
	b	2.95211	3.02487	3.02584	3.07157	3.10867	....
Profit and Loss.							
19. Receipts from sale of ore		2.61715	3.08203	2.50720	2.83601	3.48817	....
20. Profit or loss to operator	a	.37824	.03036	.53034	.27585	.37377	....
	b	.33496	.05716	.51864	.23556	.37950	....
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.02626	.39108	.22206	.07255	.78798	....
	b	.00282	.40622	.21296	.08498	.78534	....
22. Assessed valuation per ton by Board of State Tax Commissioners		....	.51957	.46544	.46981	.55920	$0.54921

a. Total of all operations.
b. Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 inclusive and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE IRON RIVER AND CRYSTAL FALLS DISTRICTS, MICH.

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.02142	$0.03991	$0.06483	$0.05912	$0.07662	$0.09376
	b	.01914	.03893	.06270	.05847	.07328	.08936
2. Fire insurance	a	.00502	.00546	.00701	.00367	.00494	.00576
	b	.00499	.00539	.00597	.00334	.00449	.00492
3. Employers liability insurance	a	....	....	.00522	.00551	.00653	.00626
	b	....	....	.00510	.00551	.00618	.00586
4. Taxes	a	.01892	.01942	.03521	.02133	.02625	.09472
	b	.01634	.01937	.03398	.02091	.02502	.08124
5. Depreciation	a	.01089	.01409	.12240	.13189	.11837	.15102
	b	.01089	.01409	.12113	.13123	.11837	.15052
6. Mining	a	1.00419	1.05856	1.25692	.98412	1.17976	1.21722
	b	.93729	1.05850	1.25692	.98017	1.17976	1.20463
7. Exploration and development	a	.26340	.34431	.22709	.10502	.25900	.20459
	b	.14520	.18955	.10211	.07084	.13150	.17734
8. Construction	a	.24753	.30177	.24661	.11833	.17559	.10170
	b	.20844	.25780	.23143	.11135	.14882	.07781
9. Total cost at mine	a	1.57137	1.78346	1.96529	1.42899	1.84706	1.87503
	b	1.34229	1.58363	1.81934	1.38182	1.68742	1.79168
"Beyond the Mine" Cost.							
10. Rail freight	a	.38136	.39229	.37714	.38548	.38549	.36687
	b	.38134	.39229	.37714	.38548	.38549	.35260
11. Boat freight	a	.56819	.57313	.37474	.43736	.47241	.32513
	b	.56814	.57313	.37474	.43736	.47241	.30924
12. Cargo insurance	a	....	....	....	.00079	.00114	.00070
	b	....	....	....	.00079	.00114	.00070
13. Analysis at lower lake ports	a	....	....	....	.00509	.00074	.00058
	b	....	....	....	.00509	.00074	.00058
14. Selling commissions	a	.08732	.08288	.09856	.07241	.07734	.06752
	b	.08732	.08288	.09856	.07241	.07734	.06395
15. Total "Beyond the Mine" cost	a	1.03687	1.04830	.85044	.90113	.93712	.76080
	b	1.03679	1.04830	.85044	.90113	.93712	.72707

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE IRON RIVER AND CRYSTAL FALLS DISTRICT, MICH.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.60824	$2.83176	$2.81573	$2.33012	$2.78418	$2.63583
	b	2.37908	2.63193	2.66978	2.28295	2.62454	2.51875
17. Royalties	a	.20623	.27628	.25170	.23845	.27167	.23104
	b	.19862	.27032	.24005	.23202	.24874	.22370
18. Total cost of delivery to operator	a	2.81447	3.10804	3.06743	2.56857	3.05585	2.86687
	b	2.57770	2.90225	2.90983	2.51497	2.87328	2.74245
Profit and Loss.							
19. Receipts from sale of ore		3.10194	3.95240	3.01281	3.27907	3.66809	2.89477
20. Profit or loss to operator	a	.28747	.84436	.05462	.71050	.61224	.02790
	b	.52424	1.05015	.10298	.76410	.79481	.15232
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.50459	1.13473	.31948	1.08084	1.00228	.40996
	b	.73375	1.33456	.46416	1.12735	1.16192	.52654
22. Assessed valuation per ton by Board of State Tax Commissioners		....	....	....	....	....	.44666

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE IRON RIVER AND CRYSTAL FALLS DISTRICTS, MICH.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.07995	$0.08637	$0.11919	$0.06907	$0.05838	....
	b	.07587	.07266	.11035	.06581	.05825	....
2. Fire insurance	a	.00586	.00733	.00616	.00512	.00410	....
	b	.00446	.00647	.00533	.00464	.00404	....
3. Employers liability insurance	a	.01008	.02012	.02950	.01907	.01887	....
	b	.00962	.01803	.02766	.01887	.01873	....
4. Taxes	a	.08153	.09690	.13931	.11820	.08226	....
	b	.06482	.08180	.11462	.10118	.07460	....
5. Depreciation	a	.11376	.12853	.13560	.09768	.10548	....
	b	.11157	.12308	.12660	.08973	.10414	....
6. Mining	a	1.10252	1.18226	1.29722	.93148	1.14334	....
	b	1.07803	1.17207	1.26056	.91655	1.13965	....
7. Exploration and development	a	.26915	.28649	.31585	.16197	.07648	....
	b	.16993	.14967	.21772	.13915	.07641	....
8. Construction	a	.19837	.30065	.21799	.08619	.11567	....
	b	.11781	.18762	.19341	.06803	.08335	....
9. Total cost at mine	a	1.86122	2.10865	2.26082	1.48878	1.49913	....
	b	1.63211	1.81136	2.05625	1.40396	1.45506	....
"Beyond the Mine" Cost.							
10. Rail freight	a	.37014	.42886	.44558	.43875	.42851	....
	b	.36538	.41676	.41958	.42991	.42851	....
11. Boat freight	a	.23496	.27170	.26330	.27286	.36345	....
	b	.23310	.26135	.24333	.26601	.36345	....
12. Cargo insurance	a	.00028	.00096	.00097	.00113	.00140	....
	b	.00028	.00092	.00089	.00110	.00140	....
13. Analysis at lower lake ports	a	.00046	.00227	.00319	.00302	.00370	....
	b	.00046	.00204	.00291	.00291	.00370	....
14. Selling commissions	a	.06269	.05675	.05355	.05622	.05342	....
	b	.06150	.05415	.04882	.05426	.05342	....
15. Total "Beyond the Mine" cost	a	.66853	.76054	.76659	.77198	.85048	....
	b	.66072	.73522	.71553	.75419	.85048	....

COSTS, PROFITS, LOSSES AND ASSESSMENTS, IRON MINES OF THE IRON RIVER AND CRYSTAL FALLS DISTRICTS, MICH.—*Concluded.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports by the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Beyond the Mine Cost.—*Con.*							
16. Total cost of delivery	a	$2.52975	$2.86919	$3.02741	$2.26076	$2.34961	....
	b	2.29283	2.54658	2.77178	2.15815	2.30554	....
17. Royalties	a	.22019	.28898	.28250	.25014	.29443	....
	b	.21170	.22626	.25786	.21777	.28215	....
18. Total cost of delivery to operators	a	2.74994	3.15817	3.30991	2.51090	2.64404	....
	b	2.50453	2.77284	3.02964	2.37592	2.58769	....
Profit and Loss.							
19. Receipts from sale of ore		2.61385	3.00108	2.63285	2.62411	2.90039	....
20. Profit or loss to operator	a	.13609	-.15709	-.67706	.11321	.25635	....
	b	.10932	.22824	-.39679	.24819	.31270	....
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.19786	.26042	-.25896	.46103	.65626	....
	b	.43259	.57758	-.01233	.55569	.69899	....
22. Assessed valuation per ton by Board of State Tax Commissioners		....	.34512	.35776	.32927	.35185	$0.37201

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, MICHIGAN IRON MINES.

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from the reports of the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.06368	$0.08084	$0.06619	$0.05704	$0.05792	$0.08406
	b	.06206	.08021	.06539	.05563	.05652	.08177
2. Fire insurance	a	.00190	.00206	.00579	.00409	.00419	.00545
	b	.00174	.00200	.00550	.00394	.00407	.00517
3. Employer's liability insurance	a	....	....	.00418	.00399	.00590	.01280
	b	....	....	.00415	.00399	.00592	.01258
4. Taxes	a	.04807	.05599	.07330	.06869	.06968	.15022
	b	.04731	.05583	.07222	.06794	.06898	.14592
5. Depreciation	a	.00481	.00636	.12127	.12421	.10092	.12972
	b	.00481	.00636	.12043	.12407	.10060	.12575
6. Mining	a	1.16233	1.29348	1.40644	1.30734	1.31023	1.39408
	b	1.14413	1.28889	1.40057	1.30143	1.30544	1.38582
7. Exploration and development	a	.10683	.14406	.12097	.09864	.13937	.15218
	b	.08433	.11399	.10066	.07897	.11135	.14150
8. Construction	a	.15695	.18758	.15741	.11996	.09994	.08838
	b	.14374	.17959	.15494	.10275	.08804	.08261
9. Total cost at mine	a	1.54457	1.77037	1.95555	1.78396	1.78824	2.01689
	b	1.48812	1.72687	1.92386	1.73872	1.74092	1.98112
"Beyond the Mine" Cost.							
10. Rail freight	a	.33341	.33639	.34304	.34590	.34547	.31765
	b	.33340	.33639	.34244	.34404	.34547	.31266
11. Boat freight	a	.53102	.53428	.48666	.49555	.53537	.37546
	b	.53101	.53428	.48638	.49555	.53537	.37108
12. Cargo insurance	a	.00066	.00080	.00006	.00150	.00182	.00159
	b	.00066	.00080	.00006	.00150	.00182	.00159
13. Analysis at lower lake ports	a	.00015	.00012	.00009	.00239	.00114	.00109
	b	.00015	.00012	.00009	.00239	.00114	.00109
14. Selling commissions	a	.03078	.03221	.03933	.04023	.03920	.03950
	b	.03078	.03221	.03917	.04023	.03920	.03834
15. Total "Beyond the Mine" cost	a	.90564	.91318	.87169	.89295	.93426	.73681
	b	.90564	.91318	.87065	.89109	.93426	.72628
Unclassified		.00964	.00938	.00251	.00738	.01126	.00152

COSTS, PROFITS, LOSSES AND ASSESSMENTS, MICHIGAN IRON MINES.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

		1906. Per ton.	1907. Per ton.	1908. Per ton.	1909. Per ton.	1910. Per ton.	1911. Per ton.
"Beyond the Mine" Cost.—*Con.*							
16. Total cost of delivery	a	$2.45023	$2.68355	$2.82724	$2.67691	$2.72250	$2.75370
	b	2.39376	2.64005	2.79451	2.62981	2.67518	2.70740
17. Royalties	a	.22560	.26862	.30007	.28448	.30499	.26209
	b	.22434	.26750	.29479	.27457	.29632	.25755
18. Total cost of delivery to operator	a	2.67583	2.95217	3.12731	2.96139	3.02749	3.01579
	b	2.61810	2.90755	3.08930	2.90438	2.97150	2.96495
Profit and Loss.							
19. Receipts from sale of ore		3.44813	4.08242	3.56079	3.59276	3.97701	3.34723
20. Profit or loss to operator	a	.77230	1.13025	.43348	.63137	.94952	.33144
	b	.83003	1.17487	.47149	.68838	1.00551	.38228
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	1.00271	1.40523	.85482	1.04006	1.35543	.72325
	b	1.05918	1.44873	.88671	1.08702	1.40243	.76555
22. Assessed valuation per ton by Board of State Tax Commissioners		....	....	....	....	....	.50435

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 inclusive and item 19 on tons shipped.

COSTS, PROFITS, LOSSES AND ASSESSMENTS, MICHIGAN IRON MINES.—*Continued.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
Cost of Mining.							
1. General office expenses	a	$0.07639	$0.06700	$0.08053	$0.06163	$0.06625	....
	b	.07408	.06275	.07648	.05995	.06580	....
2. Fire insurance	a	.00543	.00531	.00541	.00491	.00369	....
	b	.00494	.00503	.00502	.00465	.00361	....
3. Employer's liability insurance	a	.01325	.01999	.02369	.01964	.01872	....
	b	.01312	.01945	.02305	.01959	.01863	....
4. Taxes	a	.12900	.12216	.14066	.14311	.10613	....
	b	.12330	.11623	.13310	.13784	.10212	....
5. Depreciation	a	.10969	.11088	.12570	.15006	.12569	....
	b	.10759	.10815	.12009	.14570	.12444	....
6. Mining	a	1.30084	1.35877	1.29482	1.07526	1.22652	....
	b	1.29085	1.35494	1.28172	1.07070	1.22384	....
7. Exploration and development	a	.15305	.16383	.19263	.12908	.08571	....
	b	.12452	.12771	.15829	.12305	.08549	....
8. Construction	a	.10014	.19552	.17592	.09034	.12590	....
	b	.07357	.13872	.16110	.08551	.10337	....
9. Total cost at mine	a	1.88779	2.04346	2.03936	1.67403	1.63292	....
	b	1.81197	1.93298	1.95886	1.64690	1.60286	....
"Beyond the Mine" Cost.							
10. Rail freight	a	.32962	.38361	.36805	.38349	.39717	....
	b	.32606	.37900	.36085	.38129	.39717	....
11. Boat freight	a	.33031	.39878	.32625	.34823	.45780	....
	b	.32874	.39425	.31974	.34653	.45780	....
12. Cargo insurance	a	.00096	.00107	.00092	.00121	.00149	....
	b	.00095	.00106	.00091	.00120	.00149	....
13. Analysis at lower lake ports	a	.00114	.00288	.00306	.00310	.00360	....
	b	.00112	.00282	.00300	.00308	.00360	....
14. Selling commissions	a	.03668	.03930	.03609	.03737	.04117	....
	b	.03619	.03837	.03457	.03683	.04111	....
15. Total "Beyond the Mine" cost	a	.70524	.83669	.73882	.77340	.90123	....
	b	.69959	.82665	.72352	.76893	.90117	....
Unclassified		.00653	.01105	.00445	....	....	....

COSTS, PROFITS, LOSSES AND ASSESSMENTS, MICHIGAN IRON MINES.—*Concluded.*

Compiled by the Appraiser of Mines for the Board of State Tax Commissioners from reports of the operators.

		1912. Per ton.	1913. Per ton.	1914. Per ton.	1915. Per ton.	1916. Per ton.	1917. Per ton.
"Beyond the Mine" Cost.—*Con.*							
16. Total cost of delivery	a	$2.59303	$2.88015	$2.77818	$2.44743	$2.53415	....
	b	2.51156	2.75963	2.68238	2.41592	2.50403	....
17. Royalties	a	.22255	.25390	.26407	.23872	.27134	....
	b	.21800	.23582	.25783	.23136	.26648	....
18. Total cost of delivery to operator	a	2.81558	3.13405	3.04225	2.68615	2.80549	....
	b	2.72956	2.99545	2.94021	2.64728	2.77051	....
Profit and Loss.							
19. Receipts from sale of ore		2.92708	3.41137	2.92249	2.79402	3.36144	....
20. Profit or loss to operator	a	.11150	.27732	.11976	.10787	.55595	....
	b	.19750	.41592	.01772	.14674	.59093	....
21. Total profit (operator's profit or loss plus royalty and depreciation)	a	.44374	.64210	.27001	.49665	.95298	....
	b	.52309	.75989	.36020	.52380	.98185	....
22. Assessed valuation per ton by Board of State Tax Commissioners		....	.43561	.45237	.43546	.42923	$0.43439

a Total of all operations.
b Total of all operations excluding non-producers.
Note.—All items in 1906 and 1907 figured on basis of tons shipped, tons mined not available.
In all other years items 1 to 9 inclusive figured on tons mined, items 10 to 17 inclusive and item 19 on tons shipped.

PART II. NON-METALLIC MINERALS.

R. A. SMITH.

PORTLAND CEMENT INDUSTRY.

R. A. SMITH.

PORTLAND CEMENT INDUSTRY.

CLASSIFICATION OF CEMENTS.

The chief cementing materials* used in modern structural work may be classified as follows:

Nonhydraulic cements	Plaster of Paris, cement plaster, Keene's cement, etc. Common lime
Hydraulic cements	Hydraulic lime Natural cements Portland cement Puzzolan cement

For a discussion of the non-hydraulic cements the reader is referred to publications 8, 19, and 21, respectively the Mineral Resources of Michigan for 1911, 1914, and 1915.

HYDRAULIC CEMENTS.

Hydraulic cements have the property of setting under water. This property is due to the formation, during the process of burning, of compounds of lime, silica, alumina, and iron oxide, and varies greatly in the different cements. The last three given above are of chief commercial importance.

Hydraulic limes.† Limes burned at a comparatively low temperature from limestone containing 5 to 10 per cent of sand and clayey material are termed hydraulic limes. Hydraulic limes contain considerable free lime in addition to the silicates, aluminates and ferrites formed in burning, thus they will slake, though slowly, in the condition that they come from the kiln, and possess hydraulic properties. If the sandy and clayey material is much in excess of 10 percent, the resulting lime fails to slake without first being finely ground and is a true hydraulic cement.

No hydraulic limes are produced in Michigan although some strata in the Traverse formation in the northern part of the Southern Peninsula and in the Trenton limestone in the Northern Peninsula apparently have the proper composition.

Natural Cements. Natural cements are made by burning at a

*Bull, 522, U. S. Geol. Surv., 1912, Eckel, Portland Cement Materials and Industry of the United States.
†S. V. Peppel. The Uses of Limestone in Ohio, Bull. 4, p. 252, Ohio Geol. Surv. 1906.

comparatively low temperature (slightly above that for lime burning) an impure limestone containing over 10 per cent of siliceous and argillaceous matter and then grinding the product to a powder. Natural cements will not slake in the condition in which they come from the kiln but, after grinding finely, and adding water, they will set rapidly, either in air or under water. Most of the limestone from which natural cements are made in the United States contains from 13 to 35 per cent of clayey material of which 10 to 22 per cent is silica. Natural cements are usually yellow or brown in color. They are lower in specific gravity and set more rapidly than Portland cement but develop less tensile strength.

Natural cement is not made in Michigan, but certain limestones in the Traverse formation in the northern part of the Southern Peninsula appear to have the necessary composition for, and possibly some of the less magnesian portions of the Trenton limestone in the Northern Peninsula may be found satisfactory for the manufacture of natural cement.

Portland Cement. Portland cement is made by burning to incipient fusion an intimate mixture of finely pulverized and properly proportioned argillaceous and calcareous materials with the addition of such other substances, not exceeding 3 per cent, as may be necessary to control certain properties, and then grinding the resulting semi-fused mass or "clinker" to a fine powder. The mixture is usually made by mixing marl or limestone and clay or shale in such porportions that it will contain about three parts of lime to one of clayey materials. Unlike natural cement, Portland cement is made from carefully proportioned mixtures and is burned at a high temperature, approaching 3,000° F., in kilns of special design and lining. The composition* of actual mixtures ready for burning is given in the analyses below:

	1	2	3	4
	Per cent.	Per cent.	Per cent.	Per cent.
Silica ($Si\ O_2$)	12.85	12.92	13.52	14.94
Alumina (Al_2O_3)	4.92	4.83	6.56	2.66
Iron Oxide (Fe_2O_3)	1.21	1.77	....	1.10
Calcium Carbonate	76.36	75.53	75.13	75.59
Magnesium Carbonate	2.13	4.34	4.32	4.64
Total	97.47	99.39	99.53	98.93

In burning, the lime combines with the silica, alumina, and iron oxide, forming a semi-fused mass ("clinker") of silicates, aluminates and ferrites, in fairly definite proportions. The clinker is

*Min. Res. 1907, Pt. II, p. 483, U. S. Geol. Surv.

ground to a powder which is Portland cement. This is of a gray color, will set under water, is heavier than natural cements, and will develop a higher tensile strength.

Formerly 4 per cent of magnesia was considered the maximum permissible in the finished product but recent investigations by the U. S. Bureau of Standards* indicate that cements containing magnesia up to 7.5 per cent, when properly made, are satisfactory.

Puzzolan Cement. Puzzolan cement is a finely ground mechanical mixture of silliceous and aluminous materials, such as blast furnace slag or volcanic ash, and slaked lime. The mixture is not burned at any stage. When finely ground, the powder will set under water. Puzzolan cements are generally of light bluish color and of less specific gravity and tensile strength than Portland cement.

They are more adapted for use under water than in air. No Puzzolan cements are made in Michigan, though some of the blast furnaces can easily obtain abundant supplies of suitable limestone.

HISTORY† OF CEMENTS.

Ancient Cements. There seems to be no evidence that the Egyptian, Greek, or Roman builders used cements of the Portland type. The earliest known cementing materials were common limes and plasters, similar to those used today. The Romans discovered that puzzuolana, a volcanic ash found abundantly near Naples, when powdered and mixed with black lime, has hydraulic properties similar to modern hydraulic cements. Indeed, the name Puzzolan cement has been derived from this ancient cement material. The modern Puzzolan cement, however, is made chiefly from blast furnace slag. The Romans used Puzzolan cements in many of the early structures. In the Middle Ages, the use of these primitive cements seems to have been forgotten and common lime mortar was the only binding material used even in the largest buildings and structures.

Natural Cements. Lime mortar was practically the only cementing material used until near the end of the eighteenth century when Smeaton, an English engineer, discovered that the hydraulic properties of limes were due not to their purity but to their clayey impurities. In 1796, Parker, another Englishman, invented a new cement much like our modern natural cements, which he named "Roman" cement, though it was entirely different from any cement known to the Romans. Parker discovered that, when certain concretions of clay and limy matter, which were abundant in some of

*Min. Res. U. S., 1914, Part II, pp. 245-246.
†E. C. Eckel, Bull. 522, p. 18, U. S. Geol. Surv. 1913.

the coastal formations in England, were burned at a temperature slightly higher than that used in burning ordinary lime, the product would not slake in water but when powdered and mixed into a paste with water would harden not only in air but also under water. A similar cement was invented in France almost at the same time. These fore-runners of the modern natural cements soon came into general use in England and France and other parts of Europe.

During the construction of the middle division of the Erie Canal in New York, it was found that lime burned from a certain limestone in the town of Sullivan, Madison County, refused to slake. Canvass White, an associate engineer under Benjamin Wright, engineer in charge, examined and tested both the stone and the lime and decided that the stone was natural cement rock. Further tests proved the correctness of his conclusion and the first American natural cement was used extensively in the construction of the locks and walls of the middle division of the canal.

According to an analysis made in 1822 by Seybert, of a sample of the stone used, the total impurities was about 15.5 per cent and indicates that the calcined product was more a hydraulic lime than a natural cement.

The extensive use of the cement on the canal led to further search for other deposits of cement rock. Wright in a letter dated in 1820, stated that this "is found in great abundance in the counties of Madison, Onondaga, and Cayuga," thus outlining what later became the natural cement district of central New York. In the same letter he also makes the statement: "I do not know that it is found in the counties west of Cayuga, but I presume from the geological character of that country it may be found in all the country west to Niagara and propably farther west." His conclusion proved correct for within a few years cement rock was found in Erie county, the most western part of the state.

Within a few years of White's discovery, the natural cement industry had begun at a number of places in New York. The industry grew rapidly in the United States and furnished the cementing material for most of the engineering works up to the close of the nineteenth century. The industry was developed in sixteen different states, but, it never obtained a foothold in Michigan, though the state has an abundance of rock apparently suitable for the manufacture of natural cement.

Portland Cement. In 1824, Joseph Aspdin of Leeds, England, patented a process for making a cement which he called Portland cement, from a fancied resemblance to a well known English building stone—the öolitic limestone of Portland. The specifications for his patent, though vague as to the precise proportions of the raw materials and the temperature at which the mixture was to be burned, gives clearly the general method of manufacturing Portland cement by a wet mixing and grinding process. The proper proportions of the mixture and the temperature of burning were evidently known to Aspdin but were carelessly or purposely withheld from the specifications. His method tacitly specified that a pure limestone was to be burned to lime and the lime mixed with a definite quantity of clay. The mixture was to be pulverized in a wet state, dried, crushed, and then calcined in a vertical kiln. The final step was to pulverize the product to a powder which was the material Aspdin termed "Portland" cement.

Aspdin's was the chief process in use until 1875 when it was superseded by cheaper and simpler processes.

For some years the industry grew slowly in England and also on the Continent, due chiefly to the strong adherence to the use of natural cements and the necessarily higher price of Portland cement. Soon after 1850 the growth of the industry was much more rapid and Portland cement began to displace the older natural cements and gradually it became an important import into the United States.

The Portland cement industry in America, however, did not really begin until about the early seventies of the last century, when experimental manufacturing was independently begun almost simultaneously in New York, eastern and western Pennsylvania, Michigan and Maine. Apparently the first attempt in the United States to manufacture Portland cement was made at Kalamazoo, Michigan in 1872. The raw materials were marl and clay which were burned in a vertical kiln and the clinker ground by millstones. The venture was a financial failure on account of the high cost of production and the plant was abandoned in 1882.

In 1874, true Portland cement was being manufactured in western Pennsylvania from limestone and clay. There were other experimental attempts about the same time in the Hudson river district but none of these led to any development of the industry.

The foundations of the industry, however, began in the early seventies in the Lehigh region of Pennsylvania as a by-product of the natural cement industry. The experiment of selecting stone from the natural cement rock quarries, which had the proper composition for making Portland cement was begun by D. O. Saylor and his associates and resulted in the production of a small though variable tonnage of good Portland cement. Within 10 or 15 years small plants were erected in several other localities, but the industry failed to grow in the face of competition from Portland cement imported from England.

As would be expected, the American manufacturers followed closely the English methods of grinding the raw materials wet, mixing them to a paste with water, and after partially drying, forming the mixture into bricks or balls, and charging them, often by hand, into a vertical kiln for burning. After burning, the kilns were unloaded by hand and the clinker ground by millstones, a most laborious and expensive process. In England, labor was very cheap and fuel expensive; in America, labor expensive and fuel cheap. To adjust the industry to the conditions in this country, the American cement manufacturers overcame the excessive labor costs by introducing the rotary kiln and modern grinding machinery. These changes, especially the first, revolutionized the industry and gave to it an impetus which has made possible its present great development.

The Rotary Kiln. The Ransome patents taken out in 1885 in Great Britain and in 1886 in the United States are the bases from which the modern rotary kilns have been directly developed. The modern rotary kiln consists essentially of a slightly inclined steel cylinder lined with fire brick and arranged to rotate. As the kiln rotates the raw mixture is fed into the upper end and travels slowly by gravity to the lower end where it falls out as burned clinker. The fuel,—gas, petroleum, or powdered coal,—is blown in at the lower end, the flame traversing the length of the kiln.

At South Rondout, New York, it was discovered that mixed and ground materials could be charged into the kilns without wetting, thus eliminating a step from the older process. The discovery that naturally wet materials,—marl and clay, could be successfully charged into the kilns without preliminary drying was made in 1891 at Montezuma, New York. Thus originated the two principal methods now in use, the dry process used with limestone or cement rock, and the wet process, with marl. The dry process is the most economical and is almost universally used except in Michigan where most of the early plants and more than half of the present plants are using marl and so the wet process.

The Ransome kiln was designed to use producer gas but petroleum was the fuel used in the first kiln successfully operated in the United States and was the principal fuel used for a number of years. In 1895, powdered coal was substituted for petroleum and was a very important step in the development of manufacturing practice. This is now the standard fuel used in this country, except in the regions where natural gas and petroleum abound. Powdered coal is used in all of the Michigan plants.

The next most important development in the rotary kiln was its increase in size, particularly in length. By 1903, the rotary kiln had been standardized to a length of 60 feet and, with dry materials, had a rated capacity of 200 barrels of cement per day. About this time the Edison plant demonstrated that a nominal lengthening of the kiln greatly increased its capacity and a rapid lengthening began about 1905 until most of the kilns installed now are between 100 and 150 feet in length and there are in use a considerable number over 150 feet, and a few from 225 to 250 feet in length. At present no standardization of the kiln is in sight. Some of the larger kilns now in use have a capacity of over 800 barrels per day.

The success of the rotary kiln is attested by the fact that foreign Portland cement makers with cheap labor and high fuel costs have not been able to compete in American markets with the American manufacturers with cheap fuel and high labor costs.

Development in Michigan. As stated in a previous paragraph, the first attempt to manufacture Portland cement in the United States was made in 1872 at Kalamazoo, marl and surface clay being the raw materials used. The attempt was given up a number of years later on account of the excessively high cost of production.

No further attempt* was made to manufacture cement in Michigan until the Peerless Portland Cement Company was organized at Union City, Branch county, August 23, 1896. The first kilns were vertical but these were replaced by modern rotary kilns in 1902. This company is still in operation but a new plant with 84-foot rotary kilns was built in 1911 to replace the old one destroyed by fire. In 1897, the Bronson Portland Cement Company built a plant at Bronson, Branch county, and a year later, the Coldwater Portland Cement Company now the Wolverine Portland Cement Company was organized, plants being built first at Coldwater and later at Quincy. All of these plants used marl and clay or shale.

The "boom" years of the Portland cement industry in Michigan were between 1899 and 1901, twenty companies being organized in this period for the manufacture of cement from marl. Some companies made very elaborate plans but never reached beyond that stage. Only ten reached the productive stage and but five of these are now in operation. Since 1896, thirty-five different Portland cement plants have been projected or built in Michigan. Twelve are now in operation and one building.

The following is an annotated† list of all the Portland cement plants built or projected in Michigan:

*C. W. Cook, Pub. 8, Geol. Ser. 6, Mineral Resources of Michigan for 1911, p. 338.
†C. W. Cook, Cement, pp. 347-350, Pub. 8, Geol. Ser. 6. Mineral Resources of Michigan for 1911, Mich. Geol. & Biol. Surv.

TABLE I.

Name.	Location.	Capital stock and bonds.	Process.	Raw materials.
Aetna Portland Cement Co.	Fenton		Wet	Marl and clay
Alpena Portland Cement Co.	Alpena	$500,000	Dry	Limestone and clay
Bellaire Portland Cement Co.	Bellaire			
Burt Portland Cement Co.	Bellevue	Not Inc.	Dry	Limestone and shale.
Bronson Portland Cement Co.	Bronson	500,000	Wet	Marl and shale
Chamite Cement and Clay Product Co.	Bronson		Wet	Marl and Shale
Clare Portland Cement Co.	Grant to Clare Co	1,000,000	Wet	Marl and shale
Coldwater Portland C. Co.	Coldwater	300,000	Wet	Marl and shale
Detroit Portland Cement Co.	Fenton	1,000,000	Wet	Marl and clay
Eagle Portland Cement Co.	Kalamazoo		Vertical kilns	Marl and clay
Egyptian Portland C. Co.	Fenton	1,650,000	Wet	Marl and clay
Elk Portland Cement Co.	Elk Rapids	500,000	Originally wet	Originally marl and shale; later limestone.
Elk Cement and Lime Co.	Elk Rapids	750,000	Dry	Limestone and shale.
El Cajon Portland C. Co.	Alpena			
Farwell Portland Cement Co.	Farwell	525,000		
German Portland Cement Co	White Pigeon	300,000	Wet	Marl and clay
Gt. Lake Portland C. Co.	Charlevoix			
Gt. Northern Portland C. Co.	Marlborough	5,000,000	Wet	Marl and clay
Hecla Cement and Coal Co.	Bay City	5,000,000	Wet	Marl and clay
Hecla Portland Cement Co.	Bay City		Dry	Limestone and clay
Hecla (The) Co	Bay City		Dry	Limestone and clay
Huron Portland Cement Co.	Alpena	2,000,000	Dry	Limestone and shale.
Logan Portland Cement Co.	Fenton		Wet	Marl and clay
Lupton Portland Cement Co.	Lupton	1,250,000	Wet	Marl and clay
Millen Portland Cement Co.	Chelsea		Vertical kilns.	Marl and clay
Michigan Portland C. Co.	Gray Village	500,000	Wet	Marl and clay
Michigan Portland C. Co.	Coldwater	2,500,000		
Michigan Alkali Co	Wyandotte			Caustic soda and refuse and shale
New Aetna Portland C. Co.	Fenton		Wet	Marl and clay
New Bronson Portland C. Co.	Bronson	110,000	Wet	Marl and shale
New Egyptian Portland C. Co.	Fenton		Wet	Marl and clay
Newaygo Portland C. Co.	Newaygo	500,000	Wet	Limestone and shale.
Omega Portland Cement Co.	Mosherville	320,000	Wet	Marl and clay
Peerless Portland Cement Co.	Union City	1,200,000	Wet	Marl and shale
Peninsular Portland C. C.	Cement City	1,293,000	Wet	Marl and clay
Petoskey Portland C. Co.	Petoskey	1,500,000	Dry	Limestone and shale.
Pyramid Portland C. Co.	Spring Arbor	525,000	Wet	Marl and clay
Standard Portland C. Co.	Lakeland	1,000,000	Wet	Marl and clay
Standiford Portland C. Co.	Athens		Wet	Marl and clay
Three Rivers Portland C. Co.	Three Rivers	20,000	Wet	Marl and clay
Toledo Portland Cement Co.	Manchester			
Twentieth Century P. C. Co.	Fenton	750,000	Wet	Marl and clay
Wayne Portland Cement Co.	Brighton	800,000	Wet	Marl and clay
Watervale Portland C. Co.		1,000,000	Wet	Marl and clay
West German Portland C. Co.	Lima	1,000,000	Wet	Marl and clay
White Portland Cement Co.	Chelsea		Vertical kilns	Marl and clay
Wolverine Portland C. Co.	Coldwater	1,000,000	Wet	Marl and shale
Wolverine Portland C. Co.	Quincy			Marl and shale
Wyandotte Portland C. Co.	Wyandotte	1,000	Wet and dry	Limestone and clay
Zenith Portland Cement Co.	Grass Lake	1,000,000	Wet	Marl and clay

TABLE I.—*Continued.*

Fuel.	No. of kilns.	Size.	Rated capacity.	Employees.	Remarks.
Coal	8	6' x 60'	1,000		Successor to Detroit P. C. Co. See new Aetna Portland Cement Co.
Coal	6		1,000		Has not operated in two years.
					Plant never built.
Coal	8	6½' x 60'	2,000		Began producing September, 1905.
Coal.	10		1,000		See Chamite and Clay Products Co.
Coal.	10		1,000		Successor to the Bronson Portland Cement Co. See New Bronson P. C. Co.
					Plant never built.
Coal					See Michigan Portland Cement Co.
Coal.	8		1,000		See Aetna Portland Cement Co.
Coke	4		100		Suspended operations about 1882.
Coal.	9		1,200		Plants ordered sold by the courts. No operations for two years.
					See Elk Cement and Lime Co.
Coal	5		1,000		Successor to Elk Rapids Portland Cement Co. Receivers appointed Jan. 4, 1911.
					Plant never completed.
					Plant never completed.
					Never progressed beyond the newspaper stage.
Coal.					Plant dismantled.
Coal.					See Hecla Portland Cement Co.
Coal					Successor to Hecla Cement and Coal Co. See Hecla (The) Co.
Coal	6				Successor to Hecla P. C. Co. In hands of receivers. Future operations doubtful.
Coal	7	8' x 110'	5,000		
Coal					Successor to Twentieth Century Portland Cement Co. Plant never built.
Coal.					Plant never built.
Coke					Successor to the White P. C. Co. See Michigan Portland Cement Co., Gray Village.
Coal	3	8' x 125'	1,200		Successor to Millen Portland Cement Co. Began operations July 13, 1911.
					Successor to the Coldwater Portland Cement Co. See Wolverine Portland Cement Co.
					See Wyandotte Portland Cement Co.
Coal	8	6' x 60'	1,100		Successor to the Aetna Portland Cement Co.
Coal	10		1,000		Successor to the Chamite Cement & Clay Prod. Co. New company has never operated.
Coal	9	5' x 80'	1,300		Successor to Egyptian P. C. Co. in 1914.
Coal	8	6' x 90' 9' x 180'	2,250		New company incorporated June 16, 1911. Old capital stock and bonds, $3,000,000.
Coal	5		500		
Coal	9	6½' x 84'	1,800		Originally a vertical kiln plant.
Coal	3	9' x 205'	1,800		
Coal			2,000		Plant projected.
Coal					Plant never built. Marl lands now owned and operated by Peerless Portland Cement Co.
Coal					Plant never built.
Coal					Plant never built.
Coal					Plant never built.
Coal					Plant never completed.
Coal					Plant never built. See Logan Portland C. Co.
Coal					Plant never built.
Coal					Plant never built.
					Plant never built.
Coke					See Millen Portland Cement Co.
Coal	3	8½' x 225'	1,500		Successor to Michigan Portland Cement Co., Coldwater.
Coal	7	6' x 120'	1,600		
Coal	3	7' x 100'	1,000		Successor to Michigan Alkali Co.
Coal					Plant never built.

Figure 4. Geological map showing location of Portland cement plants and principle areas in which occur deposits of limestone and shale suitable for use in making Portland cement.

Legend: Cambrian,—Cls = Lake Superior sandstone; Ordovician,—Ob = Beekmantown or "Calciferous" sandstone, Ot. = "Trenton" limestone, Oc = Cincinnati shales; Silurian,—Shs = Hendricks series. Sfl = Fiborn limestone, Sms = Manistique series, Sed = Engadine dolomite, Sm = Monroe formation, Sum = Upper Monroe dolomites, Ss = Sylvania sandstone, Slm = Lower Monroe dolomites; Devonian,—Das = Antrim shale, Dt = Traverse formation, Dll = Dundee limestone; Mississippian,—Mcs = Coldwater shale, Mgr = Grand Rapids group; Upper Carboniferous,—Ccm = Coal measures.

Improvements in Grinding. In the early days of the industry, the cracker and millstones formed the chief grinding machinery but these have been replaced by larger and more efficient reducers —the gyratory crusher, which is used almost exclusively for the first stages in reduction, and the ball and tube mills for the fine stages of grinding, though there appears to be a tendency to return to some of the modified earlier types, such as the Griffin and the Huntington mills.

RAW MATERIALS.

According to Eckel*, Portland cement is an artificial product of relatively definite composition, containing approximately 60 to 65 per cent of lime, 20 to 25 per cent of silica, and 5 to 12 per cent of iron oxide and alumina.

Three general stages in manufacture are necessary in forming this product, viz., (1) intimate mixing of raw materials of proper physical and chemical composition and in the proper proportion; (2) burning of the raw mixture at a high temperature (about 3,000° F.) until it forms a semi-fused mass or clinker; and (3) grinding of the clinker to a fine powder, which is the Portland cement of commerce.

There are three general classes of raw materials required in making Portland cement, viz., (1) cement materials proper—limestone, cement rock, marl, shells, clay, shale, etc., used in making the raw cement mixture; (2) fuels—coal, oil, or gas, used for burning the mixture and furnishing power; and (3) fluxes and retarders—gypsum, lime chloride, alkalies, fluorite, etc., added at different stages of manufacture to secure certain properties in the finished cement.

The ordinary raw cement mixture, when normal natural raw materials are used, usually contains about 75 per cent of calcium carbonate, ($CaCO_3$) 20 per cent of silica (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3), and 5 per cent of magnesium carbonate, alkalies, sulphur, and other unnecessary substances.

Formerly 4 per cent was considered the limit of magnesia in the finished cement but recent investigations by the U. S. Bureau of Standards†, show that the magnesia may be 7.5 per cent or even more, if the cement is properly made.

*Bull. 522, 1913, Portland Cement Materials of the United States, p. 40.
†Min. Res. U. S., 1914, Part II, Cement, pp. 245-246.

Raw Materials Used.

Theoretically almost any combination of calcareous and siliceous argillaceous materials, which will give a composition within certain prescribed limits can be used in making Portland cement but in actual practice only those materials which naturally, or with a minimum amount of labor give the proper mixture and are abundant and easily accessible, are used. In most plants, limestone, chalk, and marl furnish the calcium carbonate; and clay and shale or slate, the silica and alumina. At some plants the lime material is the chemically precipitated calcium carbonate waste from alkali works, and at others the silica and alumina are in the form of blast furnace slag. The chief combinations of materials now used in the United States are (1) argillaceous limestone (cement rock) and high calcium limestone, (2) hard high calcium limestone and clay or shale, (3) marl and clay or shale, and (4) slag and high calcium limestone. The first two are much the more important, although the last is rapidly increasing in importance.

Since the limestone resources of Michigan are largely in the northern part of the state, and marl deposits are abundant in many localities, nearly all of the early cement companies in Michigan planned to use marl and clay or shale and, at the present time, eight of the twelve operating plants are using these materials and produce most of the marl and clay or shale cement made in the United States. The fuel costs are higher and the kiln capacity is lower when marl is used and this has caused one of the companies to use limestone. Were suitable limestone deposits available in the southern part of the state, doubtless other marl using companies would use limestone.

Marl.

The term marl is sometimes used in a loose sense to mean an indefinite mixture of clay and calcium carbonate, but from the standpoint of the cement manufacturer it refers to the nearly pure deposits of finely divided calcium carbonate found in the bottom of lakes, or beneath marshes, formerly the sites of fresh water lakes. Marl deposits are due largely to the work of organic agencies, both vegetable and animal, but the former is by far the most important. Certain algae, notably *chara fragilis,* common in many of the lakes of Michigan, are active agents in precipitating calcium carbonate from the water. Mollusca, generally of very small size thrive in the carbonated waters of marl lakes and shells of these organisms locally form from 5 to 10 per cent or more of marl deposits. All of the marl deposits in Michigan are of recent origin and in many of the lakes the process of marl formation is still going on.

There are two chief varieties of marl in the state, the white and the gray, but no sharp line can be drawn between them. The gray color is due in some places to an admixture of organic matter not found in the white variety. When wet, marl resembles a white or gray mud, but when dry, due to more or less cementation, it becomes a loosely aggregated friable mass. Marl generally contains considerable organic matter, sand, and clay. Magnesian carbonate is another impurity and this, though present generally in small amounts, usually from ½ to 3 per cent, may exceed 5 per cent or more. The various impurities in many marl deposits makes them unsuitable for use in making cement.

More than one hundred marl deposits (see Fig. 5), each above 50 acres in extent, and with an average depth of at least 10 feet, have been discovered in the Southern Peninsula of Michigan and probably this is less than one-fourth of the total number in the Peninsula. Some of the deposits are very large, the areas varying from 500 to over 1,000 acres the marl having an average depth of 20 feet or more. Numerous marl deposits are also known to exist in the Northern Peninsula. Twenty-two counties in the state contain deposits of marl with as estimated total area of 27,000 acres.

Owing to injurious impurities, unfavorable operating conditions, lack of transportation facilities, and distance from markets, suitable clays and shales, and cheap fuel supplies, many of the deposits cannot be developed for the manufacture of cement under present conditions. It will be many years, however, before the easily accessible high grade marl reserves are exhausted.

The composition of various marls now or formerly utilized for cement is given in the following tables:

*ANALYSES OF MICHIGAN MARLS, NOW OR

Locality.	Analyst.	SiO_2	Al_2O_3		Fe_2O_3	CaCO
Bronson Branch Co.	W. H. Simmons	1.75	......	1.57	......	*49.24*
Coldwater, Branch Co.	E. D. Campbell	0.52	0.51	......	0.53	51.66
Fenton, Genesee Co.	**C. W. Cook	1.13	......	0.44	......	......
Mud Lake, Genesee Co.	E. D. Campbell	0.48	0.17	......	0.51	52.28
Four Mile Lake, Washtenaw Co.	E. D. Campbell	6.66	3.17	......	1.36	*47.09*
Cobbs Lake, Hillsdale Co.	E. D. Campbell	0.20	0.50	......	0.60	50.12
Union City Branch Co.	A. Lundteigen	1.95	......	1.10	......	52.25
Goose Lake, Lenawee Co.	J. G. Dean	0.22	......	0.76	......	51.56
Spring Arbor, Jackson Co.	Delos Fall	0.58	0.76	......	......	......
Great Marl Lake, Newaygo Co.	Not given	1.24	......	0.80	......	......

ANALYSES OF MARL DEPOSITS,

Locality.	Analyst.	SiO_2	Al_2O_3	Fe_2O_3		CaCO
Grayling Lake Crawford Co.	R. C. Kedzie	1.90	0.14	......	0.10	45.16
Lupton, Ogemaw Co.	Lathbury & Spackman.	0.24	......	0.08	......	52.97
Mills' Lake, Ogemaw Co.	Lathbury & Spackman.	0.70	......	0.46	......	50.43
Pleasant Lake, St. Joseph Co.	Lathbury & Spackman.	0.84	......	0.28	......	51.28
Runyan Lake Livingston Co.	E. D. Campbell	0.28	0.65	......	0.67	52.66
Wetzel Lake, Antrim Co.	E. D. Campbell	1.44	0.28	......	0.16	51.93
White Pigeon, St. Joseph Co.	H. A. Huston	0.37	......	0.56	......	51.00
Zukey Lake	E. D. Campbell	0.96	......	......	0.62	*52.60*

*I. C. Russell, Portland Cement Industry in Michigan, 22d Ann. Rept. Pt. III, p. 650-651 U. S. G. S.

**Min. Res. Mich. for 1911, p. 341.

Figures in italics computed from analyses as reported.

FORMERLY UTILIZED FOR CEMENT MANUFACTURE.

$CaCO_3$	MgO	$MgCO_3$	SO_3	Loss on ignition.	Organic matter.	Remarks.
87.92	*0.44*	0.92	0.15	....	7.50	New Bronson Portland C. Co., Bronson.
92.25	1.37	*2.87*	0.89	....	....	Wolverine Portland C. Co., Coldwater.
91.29	......	4.58	Trace	....	1.90	Egyptian Portland Cement Co., Fenton.
93.25	1.85	*3.88*	0.55	45.72	....	New Aetna Portland Cement Co., Fenton.
84.09	*1.77*	3.72	1.25	....	....	Michigan Portland C. Co., Gray Village.
89.60	0.83	*1.74*	0.58	45.86	....	Omega Portland Cement Co., Mosherville.
93.32	......	....	......	42.40	....	Peerless Portland Cement Co., Union Cy. Marl formerly used, but now exhausted.
92.07	1.26	2.63	......	46.20	....	Peninsular Portland C. Co., Cement City.
94.75	0.99	....	0.63	....	....	Average analysis of 25 borings at Spring Arbor. Jackson Co., Marl now utilized by Peerless Portland Cement Co. at Union City.
90.90	......	2.97	......	....	4.07	Marl formerly used by Newaygo P. C. Co., Newaygo. Company now uses limestone and shale, the first shipped in from Petoskey and the second from Sec. 26, T. 32 N. R. 8 W.

PROSPECTED, BUT NOT UTILIZED.

$CaCO_3$	MgO	$MgCO_3$	SO_3	Loss on ignition. CO_2	Organic matter.	Remarks.
79.86	0.32	*0.67*	0.56	43.10	5.69	Also K_2O=0.37; Na_2O=2.65; P_2O_5=0.01 Mich. Agr. Expt. Sta. Bull. 99, 1893.
94.58	1.13	*2.37*	0.08	45.49	....	Prospectus of Lupton Portland C. Co.
90.07	1.26	*2.65*	......	47.08	....	Hecla Portland Cement and Coal Co.
91.57	1.77	....	......	45.60	....	Three Rivers Portland Cement Co.
94.00	1.75	*3.67*	0.38	42.44	....	Near Fenton.
92.75	1.15	*2.41*	0.034	44.25	....	
91.09	1.02	*2.14*	......	40.08	4.01	Prospectus German Portland Cement Co.
93.92	1.79	*2.76*	0.58	....	....	Standard Portland Cement Co.

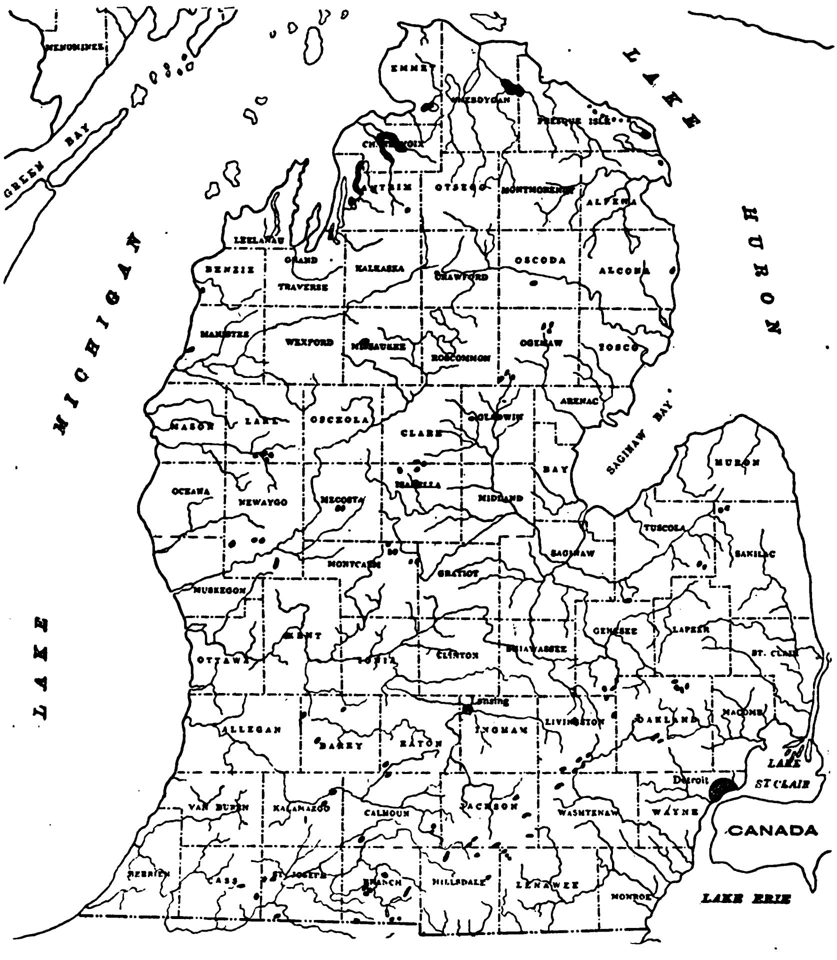

Figure 5. Map of known marl deposits in the Southern Peninsula of Michigan. The number shown is probably less than one-fourth of the total number. Adapted from Plate XLV, Cement Industry in Michigan, Pt. III, 22d Ann. Rept., U. S. G. S.

Limestone.*

Michigan has enormous limestone resources, but much of the limestone is high in magnesium carbonate and is therefore not suitable for the manufacture of Portland cement. Moreover, most of the easily accessible deposits of high calcium limestone are located in the northern part of the Southern Peninsula or in the eastern half of the Northern Peninsula far from large markets and cheap

*For a more complete discussion of the limestone resources of Michigan see Pub. 21, Geol. Ser. 17, Mineral Resources of Michigan for 1915, pp. 101-312, Mich. Geol. and Biol. Surv.

fuel supplies. The only important deposits of high calcium stone in the southern part of the state are at Sibley, Wayne county, Bellevue, Eaton County, and possibly near Dundee, Monroe county.

The principal formations containing limestone sufficiently pure to be used for Portland cement are the Bayport limestone of the Upper Mississippian, the Traverse formation and the Dundee limestone of the Devonian, and the lower portion of the "Niagara" of the Silurian.

Bayport Limestone. The principal exposures of the Bayport limestone occur near Bayport, Huron county; at several places in Arenac county; at Bellevue, Eaton county, and at many places in Jackson county. Many of the beds in the Bayport are very cherty or sandy and cannot be used for the manufacture of cement. At Bellevue, the main bed is very pure and is extensively quarried by the Burt Portland Cement Co. for making cement. Near Omer, Arenac county, it is utilized for burning chemical lime and it is suitable for the manufacture of Portland cement, but the known beds of high grade limestone in Arenac county are thin and of limited extent, or are associated with sandy and cherty limestones and sandstone. With more careful exploration probably other deposits of pure limestone will be discovered in this county. At Bayport an upper bed, averaging about 90 per cent in calcium carbonate was formerly burned for hot lime but this bed is now exhausted. Most of the other beds are very cherty, sandy, or high in magnesium carbonate and not suitable for making cement.

In Jackson county, the Bayport limestone occurs as large scattered masses buried in the drift and forms the capping on many of the rock hills. The deposits thus far discovered are either too sandy or magnesian or appear to be too small to warrant development for cement manufacture. It is possible that with more careful exploration deposits of sufficient size and purity will be found. The Bayport is underlain by calcareous shale and argillaceous limestone of the Michigan series but between the two there is a conglomerate composed of pebbles of limestone, dolomite and sandstone with a shaly matrix. The shale, where the conglomeratic zone is thin, could be utilized with the overlying limestone.

The following analyses are fairly representative of the purer phases of the Bayport limestone:

*ANALYSES OF BAYPORT (MAXVILLE) LIMESTONE.

	Analyst.	SiO_2	Fe_2O_3 Al_2O_3	$CaCO_3$	$MgCO_3$	MgO	CaO	Remarks.
S. E. ¼, Sec. 1, T. 19 N., R. 5 E. 4 mi. N. E. of Omer, Arenac Co.	R. C. Banks, Univ. Mich.	4.78	1.52	92.53	1.00	0.478	51.86	Composite sample from top of 3-foot bed in Jas. McDonnell quarry. Samples collected by R. A. Smith.
Bellevue, Eaton Co.	R. C. Banks, Univ. Mich.	2.56	1.59	94.78	1.03	0.492	53.79	Composite sample from 12-foot face on east side of quarry. Burt Ptld. Cem. Co. Samples collected by R. A. Smith.
Parma, 1 mi. N. E. of Jackson Co.	Michigan Ptld. Cem. Co., 1915.	2.74	1.26	94.32	....	Trace..	52.86	Hand samples. Anal. furnished by N. S. Potter, Jr., Gen. Mgr. Mich. Ptld. Cem. Co.
Jackson, 6 mi. N., Jackson Co.	Michigan Ptld. Cem. Co., 1915.	2.50	0.88	96.96	....	0.003	54.34	

*For other analyses of Bayport limestone see Pub. 21, Geol. Ser. 17, Min. Res. Mich. for 1915, pp. 274-277, 288-289, 294-295, Mich. Geol. and Biol. Surv.

The "Niagara" limestone underlies a broad belt in the Northern Peninsula extending from Garden Peninsula in southeastern Delta county eastward along the lake shore to Drummond Island, Chippewa county. It is widely exposed in many localities. The upper part of the formation, the Engadine dolomite and the Manistique series, is composed almost entirely of dolomite and heavy magnesian limestone. The lower part of the formation, the Hendricks series, including the Fiborn limestone, is largely high calcium and low magnesian limestone.

The Fiborn limestone is by far of most economic importance, because of its large exposures and high average purity. It is exposed or near the surface in several areas from a point five miles north of Whitedale, Schoolcraft county eastward to a point about nine miles east of Trout Lake Junction, Chippewa county, a distance of about sixty miles. The principal areas of exposures are five miles north of Whitedale and in the vicinity of Blaney quarry, Schoolcraft county; about two miles north of Huntspur, about one mile west of Gould City, four miles north of Engadine, in the vicinity of Hendricks and Fiborn quarries, and three miles west of Trout Lake, Mackinac county; and in the vicinity of Scotts' quarry about nine miles east of Trout Lake, Chippewa county. Other exposures probably occur elsewhere especially on the eastern part of Drummond Island. The deposits are very large, quarrying conditions exceptionally favorable, and the stone of excellent quality for cement manufacture, but the deposits are situated far from large markets, and cheap coal fuel supplies and most of the deposits are remote from beds of suitable clay or shale.

Known exposures of the lower beds of the Hendricks series are few and apparently of limited extent excepting perhaps the eastern part of Drummond Island. It is probable that further search will reveal the presence of other more important exposures.

The following analyses are typical of the composition of the Fiborn limestone:

Locality.	Analyst.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Remarks.
[illegible]	L. C. Nadell & C. H. Wirth, Univ. Mich.	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] Quarry, Mackinac Co.	L. C. Nadell & C. H. Wirth, Univ. Mich.	0.38		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hendricks Quarry, Mackinac Co.	L. C. Nadell & C. H. Wirth, Univ. Mich.	1.00		0.34		[illegible]	[illegible]	[illegible]	[illegible]	From … feet … [illegible]
Gould City, 1 mi. W. of, Mackinac Co.	L. C. Nadell & C. H. Wirth, Univ. Mich.	0.77		0.38		[illegible]	[illegible]	[illegible]	[illegible]	From large deposit … mile West of Gould City.

Dundee Limestone. The Dundee limestone forms a belt in the northern part of the Southern Peninsula, skirting the shore of Lake Michigan and Lake Huron from McGulpins Point, Emmet county, southeast to Presque Isle, Presque Isle county, and also underlies the surface in a narrow belt from two to nine miles wide from the eastern part of Wayne county southeast through Monroe and Lenawee counties into Ohio. It is essentially a true limestone formation, containing no dolomite and only a relatively small amount of magnesian stone except near the base of the formation. Generally it is composed of gray to buff or brown bituminous granular limestone, locally with cherty horizons. Some of the beds are remarkably pure, containing from 97 to nearly 99 per cent of calcium carbonate but some of the beds, especially near the base contain from three to over 20 per cent of magnesium carbonate.

Unfortunately the formation is extensively exposed or near the surface only in the northern and northeastern part of the Southern Peninsula far from manufacturing centers. Several relatively unimportant exposures occur in the northern part of Emmet and Cheboygan counties in the vicinity of Mackinaw City, at McGulpins Point west of the city, and along the lower course of Mill Creek four miles southeast. Very large exposures occur in the vicinity of Rogers, Adams Point, and Trout Lake, Presque Isle county. Other exposures occur elsewhere in the eastern part of the county. Near Rogers, the Dundee limestone forms a high ridge for two or three miles along the lake shore and a plateau on Adams point peninsula. The Michigan Limestone and Chemical Company of Rogers City has opened the largest quarry in the world in the eastern end of the ridge at Calcite about two miles east of Rogers. The average* of cargo analyses as shipped by the company for the season of 1914 gave 97.38 per cent calcium carbonate and only 1.81 per cent of magnesium carbonate. The Dundee in the northern part of the state is practically free from chert or siliceous impurities. The general high average purity of the stone makes it very suitable for use in cement manufacture.

In the southeastern part of the state, the Dundee limestone is exposed only at Sibley, Wayne county, at Dundee, and at the mouth of the Macon river two miles northeast of Dundee, Monroe county. Elsewhere it is deeply buried by drift. The exposures are of the lower and apparently more magnesian portion of the formation. Much of the stone is too magnesian for use in cement manufacture. Chert is also abundant at some horizons in these deposits.

The following analyses may be taken as fairly representative of the composition of the Dundee limestone in various portions of the state:

*C. D. Bradley, General Manager of the Michigan Limestone and Chemical Company.

ANALYSES OF DUNDEE LIMESTONE.

Location or quarry.	Analyst or authority.	SiO_2	Fe_2O_3 Al_2O_3	$CaCO_3$	CaO	$MgCO_3$	MgO	SO_3	Remarks
Rogers, Presque Isle Co.	Not given	0.33	0.16	98.14	......	1.16	......	0.06	Ave. analysis of core to 84 feet.
		0.34	....	97.85	54.84	1.26	0.60	......	Ave. of 235 analyses. Mich. Limestone & Chem. Co., Rogers.
Mill Creek, Cheboygan Co.	R. C. Banks, Univ. Mich.	1.67	0.73	95.29	53.34	2.11	1.00	......	Composite sample from 22 foot face.
Sibley quarry, Wayne Co., Drill Core.	Laboratory, Church & Co., Sibley.	1.98	1.67	87.63	49.11	8.72	4.17	......	Top 5 feet.
		1.90	1.82	87.26	48.90	9.02	4.31	......	5–10 feet.
		2.78	1.67	83.99	47.07	11.56	5.53	......	10–16 feet.
		2.39	1.89	81.08	45.44	14.63	6.99	......	16–20 feet.
		0.73	1.19	93.26	52.26	4.82	2.30	......	20–25 feet.
		2.21	1.96	81.81	45.84	14.02	6.70	......	25–27 feet.
		8.16	0.72	75.99	42.58	15.13	7.23	......	27–33 feet.
		7.24	0.99	82.72	46.35	9.06	4.33	......	33–55 feet.
		2.63	0.66	92.54	52.54	4.17	1.99	......	35–40 feet.
Christiancy or Macon quarry, Monroe Co.	G. A. Kirchmeier.	0.48	0.16	90.80	50.88	6.87	3.28	......	Bed A. Top.
		1.10	0.12	86.80	48.64	11.60	5.81	......	Bed B 4 ft. to 4 ft. 6 in. thick.
		2.78	0.56	77.60	43.49	17.40	8.32	......	Bed C. 7 ft. to 8 ft. thick.
		0.81	0.41	95.00	53.24	3.86	1.84	......	Bed D.

Traverse Formation. The Traverse formation is a series of limestones and blue shales, generally calcareous, with a heavy shale, the Bell, at the base. Some of the beds of limestone are very pure but many contain considerable percentages of alumina, silica, or magnesia. The interbedded shales and also the Bell shale are generally very calcareous. Locally there are coral reefs, which are of great purity. A large number of exposures occur in Alpena, Presque Isle, Cheboygan, Charlevoix, and Emmet counties and quarries are operated at Charlevoix, Bay Shore, Petoskey, Afton, Alpena, and Rockport. Only at Alpena and near Petoskey, however, is limestone quarried for the manufacture of cement. In the quarry of the Michigan Alkali Co., at Alpena, some of the beds are very shaly and the Huron Portland Cement Co. utilizes the refuse stone, i. e., stone too small or too shaly for other purposes, for the manufacture of Portland cement.

In the vicinity of Petoskey and Bay Shore, much of the limestone is too high in magnesia to be used for making cement but some of the purer beds west of Petoskey are quarried and the stone sold to Portland cement companies for this purpose.

The Petoskey Portland Cement Company was organized in the spring of 1917 and plans are under way for the erection of a modern plant on the largest developed area of high calcium stone in the Petoskey region.

The quarry of the Great Lakes Stone and Lime Company at Rockport, Alpena county, has been opened in some high calcium beds directly above the Bell shale at the base of the Traverse formation. The association of shale and low magnesian limestone coupled with a means of cheap water transportation make very favorable conditions for the establishment of a cement plant. In the quarry of the Charlevoix Rock Products Co., near Charlevoix such geologic conditions exist, a 10 foot bed of soft blue shale forming the floor of the quarry.

In general it may be stated that the Traverse formation contains an enormous amount of high calcium limestone suitable for making Portland cement.

The following table of analyses shows the variable composition of the Traverse limestones:

ANALYSES OF TRAVERSE LIMESTONE.

Locality.	Analyst.	SiO_2	Fe_2O_3 Al_2O_3	R_2O_3*	$CaCO_3$	CaO	$MgCO_3$	MgO	Organic matter.	Remarks.
Alpena, Alpena Co....	R. C. Banks, Univ. Mich.	0.41	....	0.90	90.43	*50.68*	8.31	*3.97*	....	Top beds 7 feet thick on E. side of Michigan Alkali Co. quarry to 7 feet. Composite sample collected by R. A. Smith for Mich. Geol. Surv.
Alpena, Alpena Co....	R. C. Banks, Univ. Mich.	1.13	....	0.75	94.54	*52.98*	2.61	*1.25*	....	Beds from 7-16 feet. Michigan Alkali Co. quarry. Composite sample.
Alpena, Alpena Co....	R. C. Banks, Univ. Mich.	4.03	....	1.78	92.38	*51.77*	1.80	*0.86*	....	Beds from 16-20 feet, thick. Composite sample.
Alpena, Alpena Co....	R. C. Banks, Univ. Mich.	1.46	....	0.75	95.58	*53.56*	2.11	*1.01*	....	Beds from 22 to 25 feet. Composite sample.
Alpena, Alpena Co....	R. C. Banks, Univ. Mich.	2.09	....	0.66	94.78	*53.12*	2.45	*1.17*	....	Beds 32 to 40 feet. Bottom of upper quarry. Composite sample.
Alpena County Co....	R. C. Banks, Univ. Mich.	1.05	....	1.02	96.40	*54.03*	1.52	*0.73*	....	Beds from 40 to 63 feet, lower quarry. Composite sample.
Alpena, Alpena Co....	R. C. Banks, Univ. Mich.	0.21	0.33	......	99.33	*55.67*	0.21	*0.10*	....	Ave. analysis of large blast of white coral limestone, Alpena Portland Cement Co., quarry.
Afton, Cheboygan Co. N. W. ¼, N. E. ¼, Sec. 36, T. 35 N., R. 2 E.	Not given....	2.10	0.34	......	96.52	*54.09*	0.90	0.43	0.08	Core analysis, 4 feet to 42 feet quarry of Campbell Stone Co.
Afton, Cheboygan Co..	R. C. Banks, Univ. Mich.	0.54	....	0.45	97.32	*54.54*	1.08	*0.52*	....	Top bed of Afton quarry, Campbell stone Co. Composite sample.
Afton, Cheboygan Co..	R. C. Banks, Univ. Mich.	0.63	....	0.62	92.50	*51.90*	2.56	*1.22*	2.61	From 6-foot bed of black coralline limestone. Bed rejected on account of bituminous matter.
Afton, Cheboygan Co..	R. C. Banks, Univ. Mich.	0.24	....	1.44	96.97	*54.34*	0.12	*0.05*	....	"Paper Stone" bed, 4 feet thick. Sold to paper mills.
Afton, Cheboygan Co..	R. C. Banks, Univ. Mich.	0.28	....	0.37	98.04	*54.94*	1.07	*0.51*	....	Bituminous laminated beds 8-feet in thickness. Composite sample.

Afton, Cheboygan Co..	R. C. Banks, Univ. Mich.	1.75	....	0.64	95.75	*53.66*	1.24	*0.59*	....	Lower 12 feet in quarry. Composite sample.
Petoskey, Emmet Co..	R. C. Banks,	0.09	....	0.46	62.86	*35.23*	36.44	*17.42*	....	Top corraline beds 12-18 feet thick, quarry B. of Northern Lime Co.
W. E. Smith, L. G. Grimes, et. al., property 5 mi. W. of Petoskey.	R. C. Banks,	0.71	....	0.41	93.96	*52.66*	4.65	*2.22*	....	
W. E. Smith, L. G. Grimes, et. al., property 5 mi. W. of Petoskey.	R. C. Banks, Univ. Mich.	0.26	....	0.28	94.78	*53.12*	4.18	*2.00*	....	High calcium bed, No. 6 from top Quarry B, Northern Lime Co. Composite sample.
W. E. Smith, L. G. Grimes, et. al., property 5 mi. W. of Petoskey.	R. C. Banks, Univ. Mich.	0.22	....	0.23	86.14	*47.28*	13.11	*6.27*	....	Beds Nos. 2, 3, 4, 7, and 8 from top of quarry. Composite sample.
Black Lake, Presque Isle Co.	R. C. Banks, Univ. Mich.	0.39	....	0.52	96.84	*54.27*	2.03	*0.97*	....	Samples from top to bottom of 40 foot face, Black Lake quarry, Onaway Limestone Co.
4 mi. west of Petoskey.	R. C. Banks, Univ. Mich.	1.00	....	0.81	93.00	*52.12*	4.96	*2.37*	....	From east end of quarry of Petoskey Crushed Stone Co.
2 mi. west of Charlevoix	R. C. Banks, Univ. Mich.	0.29	....	0.51	97.46	*54.62*	1.41	*0.69*	....	From top to bottom of 22 foot face, South side of quarry of Charlevoix Rock Products Co.
Rockport, Alpena Co..	R. C. Banks, Univ. Mich.	0.19	....	0.77	97.25	*54.50*	1.84	*0.88*	....	Composite sample from top to bottom of quarry of Great Lake Stone & Lime Co.

*Chiefly iron and alumina.
Figures in italics calculated.

Shales and Clays.

Suitable shales for use in cement manufacture occur in the "Utica" shale, the Cincinnati series, the Traverse, Antrim, and Coldwater formations, the Michigan series, and the Coal Measures, but, at present, shales from only the Antrim, Coldwater, and Michigan series are utilized in making cement. The surface clays are generally too sandy for this purpose.

"Utica" shale and Cincinnati Series. The so-called Utica shale and the Cincinnati series form a belt extending northeast from Green Bay, then curving eastward to St. Mary's river. The Utica is exposed only along the bed of the Whitefish river in Delta county and apparently there are but few places where quarryable conditions are favorable. The shale is black and very bituminous. Though no analyses are available, it is probable that the shale is suitable for cement manufacture.

The Cincinnati series is extensively exposed on the west side of the peninsula between Little and Big Bays de Noc. Where exposed it is very calcareous, and contains beds of limestone. Twenty-six samples of stone from a bluff near Stonington, Delta county, were analyzed by Prof. Koenig of the Michigan College of Mines and the content of calcium carbonate varied from 32 to over 66 per cent. It is possible that the beds of calcareous shale and argillaceous limestone in the vicinity of Stonington may be adapted for the manufacture of cement with a minimum admixture of pure limestone.

Traverse Shales. The Bell shale generally 50 to 80 feet thick forms the base of the Traverse formation. It underlies the surface in a narrow belt along the outer margin of the Traverse formation. It is soft, generally very calcareous, and in the northern part of the state contains thin beds of limestone. On account of its soft character it generally underlies valleys and has few exposures. It is exposed near Bell, Presque Isle county and forms the floor of Grand Lake. Probably it underlies the surface at shallow depth northwest of Grand Lake and in other places in Presque Isle county. The Bell forms the lower part of the bluff in which the Great Lakes Stone and Lime Company have opened their quarry at Rockport, Alpena county. The occurrence of shale and high calcium limestone together and near water transportation makes very favorable conditions for the manufacture of cement. A bed of shale similarly forms the floor of the Charlevoix Rock Products Co., Charlevoix, Charlevoix county.

At the Huron Portland Cement Co., Alpena, Alpena county, interbedded shale furnishes a part of the necessary siliceo-argillaceous material.

No analyses of the Bell shale or of the interbedded shales of the Traverse are available.

Antrim Shale. The Antrim shale underlies a broad arcuate belt stretching northeast from Manistee county to Cheboygan county and then southeast to Thunder Bay and into Alcona county. It is exposed at numerous points in Charlevoix, Emmet, Cheboygan, and Alpena counties. In southeastern Michigan the Antrim is deeply buried under drift. The more important deposits are near Norwood, Ellsworth, East Jordan, Boyne Falls and Walloon Lake Junction, Charlevoix county, and at Paxton, Alpena county. Numerous exposures of Antrim shale are reported to occur in the southern part of Chegoygan county. Except at the top and where weathered, the Antrim shale is generally black and very bituminous and locally contains numerous concretions of iron carbonate and nodules of pyrite. The Newaygo Portland Cement Co. at Newaygo, Newaygo county, obtains its shale from a deposit near Ellsworth in section 26, town 32 north, range 8 west, Antrim county. Other exposures of this shale which belongs to the upper blue portion of the Antrim, occur in the vicinity of Ellsworth. At Norwood the shale is black and very pyritic and forms strong bluffs along the lake shore for a half mile or more. Exposures of high calcium limestone, occur about one and one-half miles north of the village. The occurrence of suitable shale and limestone in close proximity and on water transportation routes makes a very favorable condition for the location of a Portland cement plant at this place.

The Huron Portland Cement Co., of Alpena, obtains its shale from a quarry at Paxton, 10 miles west of Alpena, Alpena county. The shale is brownish black with some blue streaks and contains so much bituminous matter that great care must be exercised in drying to prevent its taking fire. According to Mr. W. M. Smith, Chemist for the company, the average content of volatile matter is over 13 per cent and some strata contain over 18 per cent. Otherwise the shale is said to be very satisfactory for making cement.

ANALYSES OF ANTRIM SHALE.

Location.	Analyst.	SiO_2	Al_2O_3	Fe_2O_3	$CaCO_3$	$MgCO_3$	alkalies.	Water, Organ. etc.	SO_3	Fixed C.
		%	%							
*Near Alpena	A. N. Clark	55.95	17.43	7.67	2.14	1.55	2.86	12.40	....	....
Near Alpena	H. Ries	58.60	17.66	7.44	2.14	2.14	....	11.97	....	....
					CaO	MgO				
Near Alpena	W. H. Johnson	70.54	15.33	5.31	2.38	0.78	5.56	Analyses of ash. Shale as received contained 17.96 per cent of moisture and volatile matter and 6.49 per cent of fixed carbox.		

*Geol. Survey Mich. Vol. VIII, Pt. 1, p. 46.

Coldwater Shale. The Coldwater shale underlies several thousand square miles of the surface in the Southern Peninsula but it is exposed or is at shallow depth only in a few places in Branch, Huron and Sanilic counties. It is generally from 800 to 1,000 feet thick and is largely blue shale, but it contains sandy horizons and true sandstone. Locally there are many concretions of iron carbonate.

Large deposits of Coldwater shale occur near Union City, Coldwater, and Bronson, Branch county. The Wolverine Portland Cement Co., obtains its shale from a deposit near Coldwater, and the Peerless Portland Cement Co., from a quarry near Union City. The Bronson Portland Cement Company at first obtained its shale from a shallow mine near Bronson in the same county, but later used surface clays obtained from northern Ohio. Excellent but undeveloped exposures of the Coldwater shale occur along the shore of Lake Huron from Forestville, Sanilac county to White Rock, Huron county. Where the overburden is not excessive, it is probable that the Coldwater shale could be readily mined.

The range in composition of the shale at Union City and Coldwater is shown by the following analyses:

*ANALYSES OF COLDWATER SHALE.

Locality.	Analyst.	SiO_2 per cent.	Fe_2O_3 Al_2O_3 per cent.	CaO per cent.	MgO per cent.	SO_3 per cent.	Alkalies per cent.	Moisture organic, etc. per cent.
†Union City	A. Lundteigen	67.89 to 52.20	29.89 to 23.33	1.42 to 0.00	2.16 to 0.26	Trace to 0.00	8.55 to 6.00	20.50 to 10.00
†Coldwater	H. E. Brown	61.25 to 57.26	29.89 to 24.65	1.50 to 1.25	2.31 to 1.49	1.34 to .65	3.45 to 2.25	8.32 to 6.19
Bronson	‡H. Ries	62.10	27.90	0.65	0.96	0.49	....	7.90
Coldwater	‡H. Ries	53.44	24.80	0.76	0.25	....	....	20.75
White Rock	‡H. Ries	58.70	18.31	**1.80	**0.98	....	3.67	9.35

†I. C. Russell, Portland Cement Industry in Michigan, 22d Ann. Rept. U. S. Geol. Surv. Pt. III, p. 666.
‡Vol. VIII, Pt. I, p. 414, Mich. Geol. Surv.
**As carbonate.
*I. C. Russell, The Portland cement industry in Michigan, 22d Ann. Rept. pt. III, pp. 666-667, U. S. Geol. Surv.

Michigan Series. The Michigan Series is composed of greenish shales, some very calcareous, argillaceous limestones, and beds of gypsum. Some of the shales have the proper composition for use in cement but others are too high in soluble salts. At Bellevue, the Burt Portland Cement Co. utilizes greenish blue shale, and a very argillaceous limestone beneath the Bayport limestone. The composition of the shale is shown below:

ANALYSIS OF SHALE FROM BOTTOM OF CEMENT QUARRY

Analyst.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
C. H. Denman..................	59.40	11.05	3.45	13.45	2.00

Similar shale underlies the exposures of Bayport limestone north of Jackson near the mouth of the Portage River, Jackson county.

Coal Measures. The Saginaw formation or Upper Coal Measures contains an abundance of shale, though locally very sandy, but many of the beds apparently would be suitable for use in making cement. According to Ries* there are three general types of shales in the Coal Measures: first, a light gray, sandy, shaly clay, popularly called "fire clay"; second, a black, fine grained, brittle shale with dull luster, sometimes called "cannel coal"; and third, a dark grayish black, fine grained, hard, yet brittle shale. The first is low in alumina (see Anal. No. 1) and iron and of doubtful use for cement manufacture under present methods. The second, on account of the high content of bituminous and carbonaceous matter, would probably require more or less careful manipulation. The last type is associated with coal seams in Saginaw and Bay counties and is quarried at Corunna, Shiawassee county, and Flushing, Genesee county for the manufacture of paving brick. Some of the shale at Corunna is used by the Portland Cement Co, near Fenton, Genesee county for the manufacture of cement. Similar shales are mined near Bay City for making paving brick. The following analyses show that most of the shales in the Coal Measures are lower in silica than is considered desirable for use in making Portland cement under present practice but further investigations may develop methods for the satisfactory use of such shales in the manufacture of cement.

*Geol. Surv. Mich. Vol. VIII, Pt. I, 1900, pp. 25-38.

*ANALYSES OF SHALES OF THE COAL MEASURES.

Constituent.	1	2	3	4	5	6	7
Silica, SiO_2	55.30	54.50	52.45	57.10	61.13	54.93	41.38
Alumina, Al_2O_3	14.20	30.75	23.27	20.02	26.90	31.43	27.02
Ferric oxide, Fe_2O_3	3.62	3.50	7.93	8.18			
Calcium oxide, CaO	....	1.05	....	....	1.12	.22	.52
Calcium carbonate, $CaCO_3$	.30	....	1.82	.71	....	....	......
Magnesium oxide, MgO	....	1.69	....	....	.96	1.58	.90
Magnesium carbonate, $MgCO_3$	2.61	....	1.06	1.47	....	....	......
Sodium oxide, Na_2O	....	.80	4.37	2.76	(?)	(?)	(?)
Potassium oxide, K_2O	....	2.20					
Alkalies, K_2O, Na_2O	2.15	....	....	....	....	....	......
Water and organic matter	21.82	5.51	9.10	9.76	6.47	7.44	23.11
Total	100.00	100.00	100.00	100.00	96.58	95.60	92.93
Fluxes	8.68	....	....	....	....	....	......
FeO	....	1.57	1.47	....	....	....	......

1. So-called "fire clay" from Standard Mine, Saginaw.
2. Fine-grained black shale from Flushing, Genesee county; Geological Survey of Michigan, Vol. VIII, Pt. 1, 1900, p. 30. Analyst, H. Ries.
3 and 4. Shales associated with coal at Bay City, ibid., pp. 35-36. Analyst, A. N. Clark.
5, 6, and 7. Coal mines at Bay City. Analyses furnished by the Hecla Portland Cement and Coal Company. Analysts, Lathbury and Spackman.

Surface Clays.

The surface clays according to Ries† are of three general classes, —drift clays, lake clays, and river silts. The first are always calcareous except where leached at the top and generally contain sand, pebbles and boulders, and are very variable in composition. Locally lime concretions are scattered through the clays. On account of the sand, pebbles, and concretions, drift clays generally are unsuitable for cement making.

Lake clays occur in great abundance along the eastern margin of the state from Alcona county south to Ohio and in a number of localities near Lake Michigan. In the Northern Peninsula, large areas in Ontonagon, Chippewa, and southern Houghton counties are covered with heavy deposits of pinkish lake clay. The lake clays are characteristically fine-grained, generally calcareous and almost entirely free from coarse grit. The content of alumina and iron, however, is generally low in proportion to the silica and this makes them not well adapted for cement making according to present practice.

*I. C. Russell, The Portland cement industry in Michigan, 22d Ann. Rept., pt. III, p. 670, U. S. Geol. Surv.
†Geol. Surv. Mich. Vol. VIII, Pt. I, pp. 42-68.

ANALYSES OF LACUSTRAL* CLAYS.

Constituent.	1	2	3	4	5	6
Sand	....	....	1.51	....	?	......
Silica, SiO_2	49.75	49.34	66.49	47.75	46.40	61.62
Alumina, Al_2O_3	13.06	14.50	9.87	17.60	16.4	17.20
Ferric oxide, Fe_2O_3	5.31	5.37	4.87	9.13		5.99
Calcium oxide, CaO	10.86	9.75	4.72	....	....	5.62
Calcium carbonate, $CaCO_3$	....	....	....	2.60	25.36	......
Magnesium oxide, MgO	4.28	4.77	1.22	....	....	2.82
Magnesium carbonate, $MgCO_3$	....	....	....	.70	4.30	......
Sulphuric anhydride, SO_3	....	.13	.62	....	....	.46
Sodium oxide, Na_2O	?	?	?	2.21	....	......
Potassium oxide, K_2O	?	?	?			
Water, H_2O	†15.07	†15.55	†9.36	22.01	7.00	†5.34
Total	99.13	99.25	98.66	100.00	99.46	99.00

†Loss on ignition.
1. From near Chelsea, Washtenaw County. Analysis by E. D. Campbell.
2. From near Fenton, Genesee County. Analysis by E. D. Campbell.
3. From near Farmington, Oakland County, Analysis by E. D. Campbell.
4. From near Saginaw. Analysis by H. Reis: Geol. Survey Michigan, Vol. VIII, Pt. I, 1900, p. 55.
5. From near Wyandotte: used in cement making by the Michigan Alkali Company. Analysis by O. Button.
6. Sault Ste. Marie. Analysis by E. D. Campbell.

The river silts found along the margins of streams are generally too sandy for use in cement manufacture. Generally the deposits of silt are too small and thus far they have not been used for making cement.

GYPSUM.

Generally from 1 to 2 per cent of gypsum is added to Portland cement clinker before grinding to regulate the time of setting of the cement when mixed with water. The effect of gypsum is to lengthen the time before the cement begins to harden, or "to acquire its initial set." The gypsum (See Gypsum) is purchased from the various gypsum companies located near Grand Rapids and Grandville, Kent county, and at Alabaster, Iosco county.

FUEL.

All of the cement plants are now equipped with rotary kilns and crushed coal is used for burning the clinker. Most of the coal is obtained from Ohio, and West Virginia. Saginaw Valley coals have been used to a limited extent only as they are generally of lower average grade than the coals from the above mentioned states.

The coal or coke is ground to a fine dust, 98 per cent of which will pass through a 100-mesh sieve. The dust is blown into the lower end of the kilns by an air blast and upon ignition it pro-

*I. C. Russel, The Por
U. S. Geol. Surv.

duces a flame reaching the length of the kiln. The cement mixture is introduced at the opposite end and by the time it has reached the lower end of the rotating kiln it is burned to clinker. This is stored in large bins and later ground in pebble mills.

GROWTH OF INDUSTRY.

Less than 1,000,000 barrels of Portland cement were made in the United States in 1895, a little more than a fifth of the present production of Michigan. With the successful introduction of the rotary kiln in 1890, the present era of concrete construction was inaugurated. Growth from 1895 to 1907 was phenomenal, the production in the latter year nearly reaching 48,000,000 barrels. The financial depression of 1907 caused a temporary check, but growth was resumed the following year and continued almost uninterruptedly up to 1916 when the maximum of 91,521,198 barrels were produced.

In 1898 the production in Michigan was only 77,000 barrels but the next year it leaped to 343,566 barrels, and in 1901 it passed the million mark. Though hampered by low prices and keen competition the industry has maintained a relatively steady growth to the present time. The maximum production of 4,919,023 barrels was attained in 1916. This was a gain of 10.03 per cent over 1915. Both shipments and total value also were greater than in any previous year, the shipments being 5,151,818 barrels valued at $6,017,911 as compared with 4,727,768 barrels in 1915, valued at $4,454,608. The average price per barrel was $1.168 or $.224 more than in 1915. This is the highest price obtained since 1907.

All of the companies reported very prosperous conditions in 1916 and it is almost certain that 1917 will be the greatest year in the history of the industry.

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896-1916.

Year.	No. of plants in operation.	Michigan Rank.	No. of kilns, Rotary.	Daily capacity, Bbls.	Michigan, cement made. Bbls.	U. S., Cement made. Bbls.	Michigan, per cent made.	*Change per cent cement made.	Michigan, Cement shipped. Bbls.	Michigan, Cement shipped. Value.	U. S., Cement shipped. Value.	Michigan, per cent of value.	Michigan, stock on hand Dec. 31. Bbls.	Michigan, average price per barrel.	U. S., average price per barrel.
1896	1	....	....	....	4,000	1,543,023	0.25	....	....	$7,000	$2,424,011	0.29	....	$1.75	$1.57
1897	2	....	....	....	15,000	2,677,775	0.56	275.0	....	26,250	4,315,891	0.6	....	1.75	1.61
1898	2	....	....	....	77,000	3,692,284	2.11	413.3	....	134,750	5,970,773	2.3	....	1.747	1.62
1899	4	4	....	....	343,566	5,652,266	6.1	346.2	....	513,849	8,074,371	6.36	....	1.492	1.43
1900	6	2	....	....	664,750	8,482,020	7.8	93.4	....	830,990	9,280,525	8.9	....	1.25	1.09
1901	10	3	....	....	1,025,718	12,711,225	8.0	54.1	....	1,128,290	12,532,360	9.0	....	1.10	0.99
1902	10	3	....	....	1,577,006	17,230,644	9.1	53.7	....	2,134,396	20,864,078	10.2	....	1.353	1.21
1903	13	3	....	....	1,955,183	22,342,973	8.7	23.9	....	2,674,780	27,713,319	9.7	....	1.367	1.24
1904	16	4	....	....	2,247,160	26,505,881	8.5	14.9	....	2,365,656	23,355,119	10.1	....	1.052	0.88
1905	16	5	....	....	2,773,283	35,246,812	7.9	23.4	....	2,921,507	33,245,867	8.7	....	1.053	0.94
1906	14	4	....	....	3,747,525	46,463,424	8.06	35.5	....	4,814,065	52,466,186	9.2	....	1.284	1.13
1907	14	4	....	....	3,572,668	48,785,390	7.3	−4.6	....	4,384,731	53,092,551	8.1	....	1.227	1.11
1908	15	7	....	....	2,892,576	51,072,612	5.6	−19.0	....	2,556,215	43,547,679	5.8	....	0.883	0.85
1909	12	7	....	....	3,212,751	64,991,431	4.9	11.6	....	2,619,259	52,858,354	4.9	....	0.815	0.813
1910	12	8	....	....	3,687,719	76,549,951	4.8	11.7	....	3,378,940	68,205,800	4.9	....	0.916	0.891
1911	11	8	96	22,400	3,686,716	78,528,637	4.69	−0.03	....	3,024,676	66,248,817	4.56	506,758	0.82	0.843
1912	11	8	92	19,450	3,494,621	82,438,096	4.23	−5.21	3,651,094	3,145,001	69,109,800	4.55	370,956	0.861	0.813
1913	11	8	83	19,900	4,186,236	92,097,131	4.21	19.79	4,081,281	4,228,879	88,689,377	4.77	473,563	1.036	1.005
1914	11	7	77	19,100	4,285,345	88,230,170	4.85	2.37	4,218,429	4,064,781	86,437,956	4.70	538,846	0.964	0.927
1915	11	5	71	20,800	4,765,294	85,914,907	5.55	11.2	4,727,768	4,454,608	86,891,681	5.11	569,919	0.942	0.86
1916	....	....	68	20,650	4,919,023	91,521,198	5.37	10.03	5,151,818	6,017,911	94,552,296	6.36	336,477	1.168	1.058

*Minus sign indicates decrease.

MISCELLANEOUS NON-METALLIC MINERALS.

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SALT.

Both the quantity and the value of salt produced in Michigan in 1916 were greater than in any previous year. The total production in 1916 was 14,918,278 barrels valued at $4,612,567 as compared with 12,588,788 barrels in 1915 valued at $4,304,731. This represents a gain of 2,329,492 barrels or 18.5 per cent in quantity and $307,836 or only 7.3 per cent in value. The relatively small gain in value was due to the lower average price of $3.09 per barrel or $.033 less than in 1915.

From 1880 to 1892, Michigan held first rank in production in the United States. In 1893, New York gained first rank and held it continuously, with the exception of the year 1901 until 1905 when Michigan again took the lead and continued first excepting in the two years 1910 and 1911 when New York led by a narrow margin. With the exception of 1910, Michigan has also held first rank in value since 1908.

Thirty years ago the center of the salt industry was in Saginaw Valley, chiefly along Saginaw River from Saginaw to Bay City. The industry was carried on in connection with the lumber mills and waste steam and fuel from the mills were utilized by more than a hundred lumber concerns in evaporating natural brines which were obtained from the Upper Marshall sandstone at depths varying from about 600 feet in Saginaw to nearly 1,000 feet in Bay City. With the decline of the lumber industry in Saginaw Valley the salt industry became relatively unimportant. In 1915 and 1916 only 3.6 per cent of the total output of the state was produced in this district.

The war has revived the industry through the great demand for bromine from abroad. Under present conditions salt is manufactured rather as a by-product of the bromine industry. The total output for 1916 in this district was 561,164 barrels valued at $259,539.

The chief salt producing districts are in eastern Michigan along the Detroit-St. Clair rivers and in western Michigan at Ludington and Manistee. In these districts, artificial brines are used for the manufacture of salt. The brine is obtained by forcing water through casings down to rock salt beds and then back to the surface. Rock salt is mined by the Detroit Rock Salt Co. at Oakwood, a suburb on the west side of Detroit. The salt is obtained from a 20 foot bed at a depth of about 1,040 feet. The salt is shipped to large cities for curing fish, meats, and hides, for the manufacture of ice cream and for general refrigeration purposes. Over 96 per cent of the state output of salt for the last three years came from these two districts.

The salt industry in Wayne county has made a most remarkable growth. Salt was first produced in this county in 1895, the output for that year being 13,077 barrels. In 1906 the production exceeded 1,000,000 barrels and in 1916 it was 9,041,650 barrels valued at $1,210,125 or 13.34 cents per barrel. Much of the salt produced in Wayne county is in the form of brine which is used in the manufacture of soda ash, bleach, caustic, etc., and this accounts for the low average value per barrel. The Solvay Process Co., at Delray, the Michigan Alkali Co., at Ford City and Wyandotte, and the Pennsylvania Salt Co., at Wyandotte, use great quantities of brine in the manufacture of these products.

In St. Clair county, the chief salt producing centers are Port Huron, St. Clair, and Marine City. The output of St. Clair county in 1916 was only 2,469,443 barrels or 16.6 per cent of the state output, yet the value was $1,950,098 or 41.6 per cent of the total value for the state. The exceptionally high value for this county is due to the fact that much of the salt produced is of the better grades, 44.4 per cent being table and dairy salt.

In the Manistee-Ludington district, salt is made at Manistee and Filer City, on Manistee Lake, Manistee county, and at Ludington, Mason county. In this district, the salt industry is still largely carried on in connection with the lumber industry, waste steam and waste fuel being utilized for evaporating artificial brines. This district produced 2,861,736 barrels of salt valued at $1,188,805. This is equivalent to 19.2 per cent of the total quantity and 25.8 per cent of the value for the state. Most of the product is packer's salt, i. e., common fine and common coarse.

The Marshall brines especially near the center of the state contain appreciable amounts of bromine and relatively large percentages of calcium chloride. In the early days of the salt industry, the bitterns or "mother liquors" left after the precipitation of the salt by evaporation, were thrown away. The bitterns were discovered to be rich in bromine and calcium chloride and many salt and chemical plants began the recovery of bromine, chiefly in the form of bromide, and also of calcium chloride. Competition with German bromine and bromine products drove the price so low that the recovery of bromine was abandoned by all of the salt manufacturing concerns, though it was still extensively produced by the Dow Chemical Co. at Midland, Midland county. The great demand and high prices for bromine and bromine chemicals, caused by the war has revived the industry, bromine being recovered at Midland, Midland county, Saginaw, and at St. Charles, Saginaw county. Michigan produces more than half of the bromine made in the United States.

Calcium chloride is recovered as a by-product of the salt industry at Mt. Pleasant, Isabella county, and at Saginaw and St. Charles, Saginaw county. It is also produced on a large scale as a waste product by the soda ash plants in Wayne county, but, as it is not an original constituent of the brine, its value is not included in the statistics of the salt industry.

The rock salt occurs in the Salina formation of Silurian age. There are three known rock salt areas, one in southeastern Michigan, a second in Alpena and Presque Isle counties, and a third in Mason and Manistee counties. South of the line from Muskegon through Kalamazoo to Trenton, Wayne county, no rock salt has been found, though wells have penetrated completely through the rock salt bearing formation at many places. The area of rock salt in southeastern Michigan so far known extends from Trenton, Wayne county, northeast along Detroit and St. Clair rivers into western Ontario. The total area known to be underlain by rock salt in southeastern Michigan and western Ontario is several thousand square miles. The rock salt area extends northwest from Detroit River to and beyond Romulus and Dearborn in Wayne county, and Royal Oak in Oakland county but how far the salt area continues in this direction is unknown, since there are no wells northwest of these places deep enough to reach the salt bearing horizons. The aggregate thickness of the salt beds at Royal Oak and Dearborn is greater than to the southeast along Detroit River, thus indicating a considerable extension to the northwest of these places. In southeastern Michigan, the salt beds are very numerous and some of them very thick. There is an upper, thick, and apparently persistent bed from 60 to 125 feet in thickness and a lower very thick and continuous bed having a maximum thickness of over 350 feet, though it probably contains partings of dolomite or shale. The average aggregate thickness of the salt beds along Detroit and St. Clair rivers is about 400 feet, but at Royal Oak and Dearborn 609 and 556 feet of salt respectively were penetrated and at the former place the bottom of the Salina apparently was not reached.

In Alpena and Presque Isle counties, the salt area while undoubtedly very large is of unknown extent. Rock salt was struck at

Onaway, Grand Lake, and Alpena in great quantities, and the greatest aggregate thickness of rock salt yet penetrated in Michigan or Ontario, Canada, is at Onaway, Presque Isle county. A test hole drilled for oil at this place penetrated over 800 feet of rock salt in a section of 1,200 feet. The lowest bed is 225 feet in thickness, and perhaps is to be correlated with the thick bed in the Detroit river region. At Grand Lake salt beds aggregating over 300 feet in thickness were penetrated in a deep well without reaching the bottom of the rock salt formation.

In the Manistee-Ludington district, the salt beds are few and thin. In the vicinity of Manistee only one bed is known. This has a thickness of 20 to 30 feet. At Ludington, however, four beds respectively 20, 12, 7, and 5 feet in thickness have been penetrated in some wells.

The depth to the first salt bed in southeastern Michigan varies from a minimum of 730 feet at Detroit to 1,500 and 1,600 feet at Port Huron and St. Clair. The depth at Alpena, Alpena county is about 1,270 feet; at Grand Lake, 1,284 feet; and 1,630 feet at Onaway, Presque Isle county.

The total area of the rock salt districts in Michigan is unknown but it is undoubtedly several thousand square miles and present evidence, though not conclusive, indicates that the three known rock salt districts are but parts of the same great rock salt area.

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES, 1860-1916.

Year.	U. S. Production. Quantity, bbls.	Michigan production. State Salt Inspectors.* Quantity, bbls.	Michigan production. U. S. G. S.† Quantity, bbls.	Per cent of total. Michigan.	Rank. Quantity.	Value. Michigan.	Michigan. Rank-Value.	Michigan. Price, bbl.
1860	......	4,000	......	......	....	......	......	......
1861	......	125,000	......	......	....	......	......	......
1862	......	243,000	......	......	....	......	......	......
1863	......	466,000	......	......	....	......	......	......
1864	......	529,073	......	......	....	......	......	......
1865	......	477,200	......	......	....	......	......	......
1866	......	407,997	......	......	....	$734,395	......	$1.80
1867	......	474,721	......	......	....	840,255	......	1.77
1868	......	555,690	......	......	....	1,028,027	......	1.85
1869	......	561,288	......	......	....	786,835	......	1.58
1870	......	621,352	......	......	....	820,185	......	1.32
1871	......	728,175	......	......	....	1,063,135	......	1.46
1872	......	724,481	......	......	....	1,057,742	......	1.46
1873	......	821,346	......	......	....	1,127,984	......	1.37
1874	......	1,026,970	......	......	....	1,220,094	......	1.19
1875	......	1,081,856	......	......	....	1,190,042	......	1.10
1876	......	1,482,729	......	......	....	1,556,865	......	1.05
1877	......	1,660,997	......	......	....	1,411,847	......	0.85
1878	......	1,855,884	......	......	....	1,577,501	......	0.85
1879	......	2,058,040	......	......	....	2,099,200	......	1.02
1880	5,961,060	2,676,588	2,485,177	41.69	1	2,271,931	......	0.75
1881	6,200,000	2,750,299	......	44.35	1	2,418,171	......	0.85
1882	6,412,373	3,037,317	3,037,317	47.36	1	2,126,122	......	0.70
1883	6,192,231	2,894,672	2,894,672	46.74	1	2,344,684	......	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648	......	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	1	2,967,663	......	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	1	2,426,989	......	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	1	2,291,842	......	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	1	2,261,743	......	0.585
1889	8,005,565	3,846,979	3,856,929	48.17	1	2,088,909	......	0.541
1890	8,776,991	3,838,637	3,838,632	43.72	1	2,302,579	......	0.600
1891	9,987,945	3,927,671	3,966,748	39.52	1	2,037,289	......	0.513
1892	11,698,890	3,812,504	3,829,478	32.81	1	2,046,963	......	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	2	888,837	......	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619	......	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	2	1,048,251	......	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	2	718,408	......	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	2	1,243,619	......	0.313
1898	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081	......	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2	2,205,924	......	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2	2,033,731	2	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	1	2,437,677	1	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	2	1,535,823	2	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	2	1,119,984	2	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	2	1,579,206	2	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1	1,851,332	2	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	1	2,018,760	2	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	1	2,231,129	2	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	1	2,458,303	1	0.241
1909	30,107,646‡	6,055,661	9,966,744	33.10	1	2,732,556	1	0.274
1910	30,305,656‡	5,597,276	9,452,022	31.18	2	2,231,262	2	0.236
1911	31,183,968‡	......	10,320,074	33.10	2	2,633,155	1	0.255
1912	33,324,808‡	......	10,946,739	32.84	1	2,974,429	1	0.277
1913	34,393,227‡	......	11,528,800	33.52	1	3,293,032	1	0.285
1914	34,402,772‡	......	11,670,976	33.92	1	3,299,005	1	0.283
1915	38,231,496‡	......	12,588,788	32.93	1	4,304,731	1	0.342
1916	......	......	14,918,278	......	1	4,612,567	1	0.309
Tot'l.	......	......	236,724,878	......	....	$98,815,061	......	......

*Office of State Salt Inspector abolished in 1911.
†In cooperation with the Michigan Geological Survey after 1909.
‡Includes production of Hawaii and Porto Rico, 1909-1913, 1915-1916 and of Porto Rico in 1914.

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY GRADES, 1906-1916.

Year.	Table and dairy.		Packers. Common fine.		Packers. Common coarse.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906	509,905	$362,366	2,927,478	$757,470	2,021,287	$618,727
1907	657,509	392,641	3,601,270	914,154	1,743,840	471,378
1908	584,452	620,647	3,454,062	966,617	2,020,956	610,286
1909	585,370	732,907	3,530,303	1,125,095	2,103,719	647,878
1910	726,434	565,653	2,216,181	734,828	1,992,465	596,301
1911	817,486	742,702	2,362,075	698,203	2,070,745	745,720
1912	905,593	920,782	2,225,337	645,692	2,066,492	835,673
1913	1,028,000	1,037,402	2,704,936	852,135	2,259,164	896,521
1914	1,092,344	1,025,164	2,668,969	911,016	2,380,378	870,715
1915	1,233,117	1,420,382	3,096,644	1,181,337	2,265,352	1,001,167
1916	1,305,950	1,461,085	3,109,857	1,221,901	2,133,600	1,064,709

Year.	Packers.		Other, rock, etc.		Brine and other. *	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906	91,098	$33,733			4,387,043	$246,462
1907	119,459	48,455			4,664,552	235,729
1908	134,726	53,669			3,991,083	205,084
1909	93,357	3,983			3,648,395	185,051
1910	92,426	43,942			4,104,934	211,317
1911	105,401	45,421	576,595	$181,865	4,387,772	219,244
1912	223,866	84,638	763,908	250,680	4,737,038	236,852
1913	50,557	25,371	727,364	244,172	4,756,779	237,431
1914	†	†	712,530	252,024	4,816,735	240,086
1915	†	†	919,735	321,354	5,073,940	380,491
1916	†	†	1,012,942	368,022	7,365,927	506,850

Year.	Total. Quantity.	Total. Value.
	Barrels.	
1906	9,936,802	$2,018,760
1907	10,786,630	2,062,357
1908	10,194,270	2,458,303
1909	9,966,744	2,732,556
1910	9,452,022	2,231,262
1911	10,320,074	2,633,155
1912	10,946,739	2,974,429
1913	11,528,800	3,293,032
1914	11,670,976	3,299,005
1915	12,588,788	4,304,731
1916	14,918,278	4,612,567

*Brine only after 1910.
†See common fine and common coarse after 1913.

GYPSUM.*

From 1868 to 1890, the annual production of gypsum in Michigan never reached 70,000 tons; the production in the latter year, however, attained the maximum of 74,877 tons. The maximum value of gypsum and gypsum products was attained in 1883, the value being $377,567. The growth of the industry began in 1890. The output reached 139,557 tons in 1892 but the financial depression throughout the country during 1892-3 disorganized the industry, the production decreasing in 1895 to only 66,519 tons, or less than half that in 1892. From 1896 to the present, the growth has been almost uninterrupted reaching the maximum production of 457,375 tons in 1916, valued at $1,066,588. This represents a gain in amount and value over 1915 of 67,384 tons, or 17 per cent in amount and $380,290 or 57 per cent in value. The large gain in value is due largely to war conditions.

In the early days of the gypsum industry, four-fifths of the raw gypsum was ground into land plaster and from 1869 to 1887 more than half of the gypsum mined was ground into this product. With the more general use of patent fertilizers, the demand for land plaster has more or less gradually decreased so that the production in 1916 was only 9,072 tons as compared with the maximum of 44,972 tons in 1873.

The growth of the gypsum industry is due largely to the invention and introduction into the building trades of gypsum plasters, plaster board, fire-proofing, calcimines, and other gypsum products. Since 1887, the grinding of land plaster has become relatively insignificant in comparison with the manufacture of building products. In 1916, the value of land plaster was only $16,658 as compared with $975,626 for calcined products.

The most important of these products is mixed wall plaster. In 1916 this product was valued at $668,795, or 62.7 per cent of the total value of raw and calcined products for the state. Stucco is next in importance with a value of $279,597, or 26.2 per cent of the total value. The value of these two products is practically 90 per cent of the total value for the state.

In 1916, five mines, two quarries and eight mills were in operation. One mill was abandoned at Grand Rapids but another was erected by the United States Gypsum Co., at Detroit. Five mines, one quarry and six mills are located at Grand Rapids, Kent county, one quarry and mill at Alabaster, Iosco county, and one mill at Detroit. At least three, and probably four, gypsum beds are

*For a more complete report on the gypsum industry of Michigan, see Pub. 19, Geol. Ser. 16, Min. Res. of Mich. for 1914, Mich. Geol. & Biol. Surv.

worked in Kent county. The two upper beds at Grand Rapids, respectively 6 and 12 feet thick, are near the surface. Formerly these were quarried but, because of the heavy overburden and water troubles which were increasing with the progress of quarrying the quarries have given place to mines. In the western part of Grand Rapids a third bed about 22 feet thick with a parting of shale one-feet thick near the center occurs about 60 feet below the surface. At Grandville an upper bed, about 11 feet thick is directly overlain by sand and gravel and is separated below from a 14-foot bed of gypsum by about four feet of hard limestone. These two beds may be equivalent of the 22-foot "split" in West Grand Rapids. The upper bed was formerly quarried but, because of heavy overburden and water the quarries have been replaced by mines opened in the lower bed. Numerous explorations show that there are several other minable gypsum beds in the Grand Rapids-Grandville district.

In the Alabaster district the upper gypsum bed, which is extensively quarried at Alabaster is from 18 to 23 feet thick. Test holes north of Alabaster show the presence of a number of deeper gypsum beds, 5 to 25 feet thick.

In the vicinity of Turner, Twining, and the deserted village of Harmon City, Arenac county, a bed of gypsum, called the Turner bed occurs 50 to 100 feet above the Alabaster bed. Locally, as in the vicinity of Turner, this bed is of minable thickness.

Gypsum beds occur on St. Ignace Peninsula and on St. Martins and other adjacent islands. Test holes in the vicinity of St. Ignace are reported to show beds of gypsum totalling 60 feet in thickness, three of the beds being 9, 13, and 21 feet thick respectively.

Available data indicates the presence of seven quarryable beds of gypsum in this district, but locally it is probable that water will be troublesome.

Gypsum was quarried near Pt. Aux Chenes as early as 1850. On account of various troubles, chief of which were water and a scourge of smallpox, the quarry was operated only intermittently for a number of years. Finally, when an ice-floe carried away the dock, the quarry was abandoned.

Thick gypsum beds are reported by well drillers in the vicinity of Ionia, Ionia county, and Cass City, Tuscola county, and beds 6 to 12 feet thick are known at comparatively shallow depths at Bellevue, and Eaton Rapids, Eaton county. In brief, the gypsum deposits of Michigan may be said to be practically inexhaustible.

PRODUCTION OF GYPSUM IN MICHIGAN, 1868-1916.

Year.	Ground into land plaster. Tons.	Gypsum calcined into plaster. Tons.	Sold crude. Tons.	Total production. Tons.	Total value.	Rank. Quantity.	Rank. Value.
Before 1868.	132,043	14,285	....	146,328	$671,022	....	....
1868.......	28,837	6,244	....	35,081	165,298	....	....
1869.......	29,996	7,355	....	37,351	178,824	....	....
1870.......	31,437	8,246	....	39,683	191,718	....	....
1871.......	41,126	8,694	....	49,820	234,054	....	....
1872.......	43,536	10,673	....	54,209	259,524	....	....
1873.......	44,972	14,724	....	59,696	297,678	....	....
1874.......	39,126	14,723	....	53,849	274,284	....	....
1875.......	27,019	10,914	....	37,933	195,386	....	....
1876.......	39,131	11,498	....	50,629	248,504	....	....
1877.......	40,000	9,819	....	49,819	238,550	....	....
1878.......	40,000	8,634	....	48,634	229,070	....	....
1879.......	43,658	9,070	....	52,728	247,192	....	....
1880.......	49,570	18,929	....	68,499	349,710	....	....
1881.......	33,178	20,145	....	53,323	293,872	....	....
1882.......	37,821	24,136	....	61,957	344,374	....	....
1883.......	40,082	28,410	....	68,492	377,567	....	....
1884.......	27,888	27,959	....	55,847	335,382	....	....
1885.......	28,184	25,281	....	53,465	286,802	....	....
1886.......	29,373	27,370	....	56,748	308,094	....	....
1887.......	28,794	30,376	....	59,170	329,392	....	....
1888.......	22,177	35,125	....	57,302	347,531	....	....
1889.......	19,823	36,800	....	56,623	353,869	....	....
1890.......	12,714	47,163	15,000	74,877	192,099	....	....
1891.......	15,100	53,600	11,000	97,700	223,725	....	....
1892.......	14,458	77,599	47,500	139,557	306,527	....	....
1893.......	16,263	77,327	31,000	124,590	303,921	....	....
1894.......	11,982	47,976	20,000	79,958	189,620	....	....
1895.......	9,003	51,028	6,488	66,519	174,007	....	....
1896.......	6,582	60,352	700	67,634	146,424	....	....
1897.......	7,193	71,680	16,001	94,874	193,576	....	....
1898.......	13,345	77,852	1,984	93,181	204,310	....	....
1899.......	17,196	88,315	39,266	144,776	283,537	....	....
1900.......	10,354	86,972	33,328	129,654	285,119	2	2
1901.......	9,808	129,256	46,086	185,150	267,243	1	1
1902.......	13,022	158,320	68,885	240,227	459,621	1	1
1903.......	18,409	198,119	52,565	269,093	700,912	1	1
1904.......	18,294	185,422	34,669	238,385	541,197	1	1
1905.......	20,285	203,313	24,284	247,882	634,434	1	2
1906.......	30,220	208,715	27,517	341,716	753,878	1	2
1907.......	15,500	197,666	36,543	317,261	681,351	3	3
1908.......	11,414	192,403	40,324	327,810	491,928	1	3
1909.......	11,890	344,171	45,781	394,907	1,213,347	2	1
1910.......	7,097	240,905	64,566	357,174	667,199	2	2
1911.......	15,548	206,299	79,050	347,296	523,926	3	4
1912.......	10,103	243,656	63,819	384,297	621,547	2	3
1913.......	9,604	278,368	60,706	423,896	721,325	3	3
1914.......	9,322	249,648	61,227	393,006	705,841	3	3
1915.......	9,799	245,484	60,572	389,791	686,309	3	4
1916.......	9,072	292,109	80,298	457,375	1,066,599	....	....
Totals..	1,251,348	4,723,228	1,078,159	7,741,742	$19,998,219	....	....

PRODUCTION OF GYPSUM IN MICHIGAN, 1911-1916.

Year.	Crude gypsum mined.	Gypsum sold crude.							
		To Portland cement mills.		As land plaster.		For other purposes.		Total sold crude.	
	Quantity.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	Tons.		Tons.		Tons.		Tons.	
1911	347,296	63,489	$69,497	15,548	$15,706	13	$52	79,050	$85,255
1912	384,297	53,711	52,420	10,103	9,375	5	50	63,819	61,845
1913	423,896	*	*	9,604	10,222	10,320	9,011	60,706	55,969
1914	393,006	*	*	9,322	10,761	....	....	61,227	51,242
1915	389,791	*	*	9,799	9,894	*	*	69,572	63,236
1916	457,375	....	....	9,072	16,658	....	....	80,298	90,973

Year.	Gypsum sold calcined.									
	As mixed wall plaster.		As plaster of Paris, etc.		As stucco.		As dental plaster.		To plate glass works.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.	
1911	146,920	$381,362	47,989	$88,168	....	....	20	$110	11,370	$19,031
1912	146,099	368,676	937	3,229	82,010	$168,734	3	12	6,214	8,078
1913	166,711	437,720	*	*	95,402	202,675	*	*	*	*
1914	163,972	475,638	*	*	83,780	173,172	*	*	....	....
1915	155,861	426,432	*	*	80,172	177,317	*	*	*	*
1916	193,816	668,795	224	1,325	87,405	279,597	*	*	*	*

*Included in total.

PRODUCTION OF GYPSUM IN MICHIGAN, 1911-1916.—*Concluded.*

Year.	Gypsum sold calcined.				Total value.	Kettles in mills.		Daily capacity.	Shifts run by mills during year.		No. mines and quarries.	No. mills.
	For other purposes.		Total sold calcined.									
	Quantity.	Value.	Quantity.	Value.		No.	Size.	24 hrs.	Total No.	Hrs. in shift.		
	Tons.		Tons.									
1911	....	....	206,299	$488,671	$573,926	29	8 x 10	2,200	....	....	8	8
1912	8,393	$10,973	243,656	559,702	621,547	28	8 x 10	2,140	1,850	11	6	8
1913	9,897	15,850	278,368	665,356	721,325	28	8 x 10	1,785	1,368	11	7	8
1914	1,811	5,433	249,648	654,599	705,841	28	8 x 10	1,860	2,043	11	8	8
1915	*	*	245,484	623,073	686,309	26	8 x 10	....	....	....	8	8
1916	*	*	292,109	975,626	1,066,599	26	10 x 12	....	....	....	8	8

COAL.*

Coal mining began in Michigan as early as 1835 but no records of production are available before 1860, when Michigan was credited with an output of 2,320 tons. Most of the coal in the early days was obtained from veins exposed or at shallow depth in the vicinity of Grand Ledge, Eaton county, Jackson, Jackson county, and Corunna, Shiawassee county. Ten years later the production reached 28,150 tons, in 1880, 100,800 tons, and for the following two years it exceeded 100,000 tons annually. In 1883, a sharp decline began and in the following year the production fell to only 36,712 tons. It was not until 1897 that the production again exceeded the 100,000 ton mark. In that year, the Saginaw and Bay county fields were opened and the production jumped to 223,592 tons. The industry grew rapidly and four years later, in 1901, the production was nearly one and a quarter million tons. The maximum output of 2,035,858 tons was reached in 1907. Following that year a rapid decline set in and continued until the maximum of production for 1913 was 1,138,699 tons. The production has remained practically stationary since. According to the State Coal Mine Inspector, the total coal sales for the year ending November 30, 1916, were 1,076,215 tons. This does not include coal used for steam and heat, therefore, it is probable that the total production is practically the same as in 1915.

The scarcity of coal and the resulting high prices in the winter and spring of 1917 has given a new impetus to the industry and probably the production in 1917 will show a large increase. The output, however, has been curtailed more or less by a shortage of cars and doubtless this will be the condition for most of 1917.

*For a more complete report on the coal industry in Michigan see Publication 19, Geol. Ser. 16, Mineral Resources of Michigan for 1914, pp. 247-270, also Vol. VIII, Pt. 2, Coal, by A. C. Lane.

PRODUCTION OF COAL IN MICHIGAN, 1869-1916, IN SHORT TONS.

Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.
1860	2,320	1871	32,000	1882	135,339	1893	45,979	1904	1,342,840
1861	3,000	1872	33,600	1883	71,296	1894	70,022	1905	1,473,211
1862	5,000	1873	56,000	1884	36,712	1895	112,322	1906	1,346,338
1863	8,000	1874	58,000	1885	45,178	1896	92,882	1907	2,035,858
1864	12,000	1875	62,500	1886	60,434	1897	223,592	1908	1,835,019
1865	15,000	1876	66,000	1887	71,461	1898	315,722	1909	1,784,692
1866	20,000	1877	69,197	1888	81,407	1899	624,708	1910	1,534,967
1867	25,000	1878	85,322	1889	67,431	1900	849,475	1911	1,476,074
1868	28,000	1879	82,015	1890	74,977	1901	1,241,241	1912	1,164,973
1869	29,980	1880	100,800	1891	80,307	1902	964,718	1913	1,138,639
1870	28,150	1881	112,000	1892	77,990	1903	1,367,619	1914	1,283,030
								1915	1,156,138
								*1916	1,076,215

*Report of State Coal Mine Inspector, State Department of Labor.

PRODUCTION, COST OF MINING, PROFITS, AND VALUE OF COAL IN MICHIGAN, 1900-1916.

Year.	*Number active mines.	Average number employees per month.	**Average daily wage.	†Total tons of coal mined.	Total cost of coal mined.	Average cost per ton.	***Total tons of coal mined.	***Total value of coal mined.	***Average price received per ton.	‡Profit made per ton.
1900	31	1,676	$2 34	871,388	$1,209,228	$1.387	849,475	$1,259,683	$1.483	$0.096
1901	30	1,847	2 44	1,016,496	1,442,415	1.419	1,241,241	1,753,064	1.412	.007
1902	32	1,616	2 75	899,967	1,284,342	1.427	964,718	1,653,192	1.714	.287
1903	34	3,014	2 91	1,601,984	2,529,027	1.579	1,367,619	2,707,527	1.979	.400
1904	33	2,733	3 01	1,408,375	2,266,098	1.609	1,342,840	2,424,935	1.806	.197
1905	38	2,776	2 96	1,413,307	2,244,434	1.588	1,473,211	2,512,697	1.705	.117
1906	38	2,106	2 40	1,367,385	2,090,489	1.529	1,346,338	2,427,404	1.803	.274
1907	37	2,897	3 24	1,911,201	3,162,837	1.655	2,035,858	3,660,833	1.798	.143
1908	38	3,115	3 02	1,842,778	3,089,759	1.677	1,835,019	3,322,904	1.811	.134
1909	36	2,907	2 93	1,736,573	2,865,083	1.650	1,784,692	3,199,351	1.793	.143
1910	34	2,471	3 07	1,462,276	2,626,342	1.796	1,534,967	2,930,771	1.909	.103
1911	32	2,539	3 39	1,389,585	2,623,244	1.887	1,476,074	2,791,461	1.891	.004
1912	26	1,886	3 19	1,160,768	2,170,076	1.869	1,201,230	2,399,451	1.989	.120
1913	24	2,076	3 49	1,138,163	2,250,559	1.977	1,231,786	2,455,227	1.993	.016
1914	23	2,146	3 35	1,153,869	2,285,281	1.99	1,283,030	2,559,786	1.99	.000
1915	20	1,942	3 45	1,069,798	1,929,386	1.77	1,156,138	2,372,797	2.05	.280
1916	18	1,794	3 57	1,076,215	2,049,812	1.90	....	....	....	....

*Compiled and adapted from reports of State Coal Mine Inspector, Ann. Repts. State Department of Labor.
**For year beginning Dec. 1 and ending Nov. 30.
***From Mineral Resources of United States, U. S. G. S.
†Does not include coal used for steam and heat.
‡Not including depreciation, interest on capital invested, etc.

PRODUCTION, COST OF MINING, ETC., OF COAL IN MICHIGAN BY COUNTIES AND MONTHS IN 1916.*

Counties.	No. of active mines.	No. of employees.‖	Aver. No. hours worked per day.	Aver. No. days worked per month.	Average daily wages.	Aggregate amount paid in wages.	No. mines using powder.	No. kegs of powder used.	No. tons of picked coal mined.	No. tons of machine coal mined.	Total No. tons of coal mined.	Aver. cost per ton.	Total cost of output.
December													
Bay...........	6	1,029	7.8	25.3	$3 55	$92,441 83	6	1,070	17,772	46,621	64,393	$1 86	$120,169 67
Saginaw........	9	939	7.0	23.2	3 28	71,501 49	7	803	6,478	52,336	58,814	1 59	93,523 64
Other counties..	18	247	....	....	....	19,937 26	2	....	1,649	4,662	6,311	1 89	11.908 82
Total......	18	2,215	7.9	24.3	$3.40	$183,880 58	15	1,979	25,899	103,619	129,518	$1 74	$225,602 13
January													
Bay...........	7	1,166	7.9	21.4	$3 55	$89,052 08	7	1,003	13,472	49,987	63,461	$1 79	$114,201 01
Saginaw........	6	813	8.0	23.1	3.47	64,289 08	5	743	7,917	45,472	53,389	1 64	87,821 14
Other counties..	......	203	....	....	....	15,103 17	2	....	1,572	4,603	6,175	2 10	12,988 54
Total......	18	2,182	7.9	22.3	$3.48	$168,444 33	14	1,850	22,961	100,062	123,023	$1 74	$215,010 69
February													
Bay...........	5	892	7.9	18.9	$3 61	$61,900 55	5	739	11,642	35,811	47,453	$1 78	$84,515 96
Saginaw........	7	935	7.9	19.5	3 46	63,510 26	7	588	7,145	44,029	51,174	1 60	81,992 93
Other counties..	......	183	....	....	....	11,789 33	1	....	1,338	3,953	5,291	1 93	10,213 85
Total........	16	2,010	7.9	19.2	$3 54	$137,200 14	13	1,424	20.125	83,793	103,918	$1 70	$176,722 74
March													
Bay...........	5	893	7.9	24.4	$3 58	$68,869 50	4	912	8,949	46,497	55,446	$1 83	$101,757 61
Saginaw........	7	902	7.9	22.4	3 44	70,751 52	7	628	5,263	48,045	53,308	1 74	93.231 85
Other counties..	......	186	....	....	....	....	1	....	1,356	4,131	5,487	1 94	10,633 84
Total......	16	1,981	7.9	23.1	$3 29	$150,452 33	12	1,629	15,568	98,673	114,241	$1 79	$205,623 30

PRODUCTION, COST OF MINING, ETC., OF COAL IN MICHIGAN BY COUNTIES AND MONTHS IN 1916.—*Concluded**

Counties.	No. of active mines.	No. of employees.	Aver. No. hours worked per day.	Aver. No. days worked per month.	Average daily wages.	Aggregate amount paid in wages.	No. mines using powder.	No. kegs of powder used.	No. tons of picked coal mined.	No. tons of machine coal mined.	Total No. tons of coal mined.	Aver. cost per ton.	Total cost of output.
April													
Bay	5	857	7.9	17.3	$3 69	$54,708 30	5	603	9,871	28,817	38,688	$2 02	$78,379 34
Saginaw	7	711	7.7	13.7	3 64	35,456 14	6	312	1,419	26,803	28,222	1 88	53,069 18
Other counties	.....	185	....	....	....	....	1	....	532	1,417	1,949	1 90	3,696 83
Total	16	1,753	7.8	15.0	$3 42	$90,325 24	12	949	11,822	57,037	68,859	$1 96	$135,145 35
May													
Bay	4	548	7.7	20.8	$3 53	$42,596 00	3	488	6,624	24,810	31,434	$1 84	$58,089 52
Saginaw	6	650	7.9	16.4	3 60	38,741 38	6	349	3,948	25,274	29,222	1 87	54,934 28
Other counties	.....	139	....	....	....	....	0	....	591	1,812	2,403	1 90	4,539 83
Total	13	1,337	7.8	17.9	$3 32	$86,563 38	9	837	11,163	51,896	63,059	$1 86	$117,563 63
June													
Bay	4	519	7.8	20.3	$3 77	$39,719 59	3	396	4,919	21,872	26,791	$2 08	$55,945 13
Saginaw	6	689	7.9	17.9	3 69	45,509 14	4	363	2,661	30,456	33,117	1 90	63,238 88
Other counties	.....	15	....	....	....	....	0	....	....	....	....	.....	568 50
Total	12	1,223	7.8	18.1	$3 72	$85,545 43	7	1,077	7,580	52,328	59,908	$2 29	$119,751 51
July													
Bay	5	770	7.9	19.8	$3 73	$54,189 50	5	403	8,073	16,900	24,973	$2 94	$73,537 41
Saginaw	5	692	7.5	15.2	3 73	39,596 76	5	278	4,071	20,004	24,075	2 36	56,878 89
Other counties	.....	145	....	....	....	....	1	....	1,119	4,158	5,277	1 93	10,162 18
Total	13	1,607	7.9	18.1	$3 59	$103,690 76	11	744	13,263	41,062	54,325	$2 58	$140,578 48

August													
Bay	4	628	7.8	22.1	$3 84	$52,643 87	4	342	7,050	20,620	27,670	$2 51	$69,568 64
Saginaw	7	760	7.9	20.4	3 91	59,762 74	7	602	6,633	34,076	40,709	1 98	80,840 35
Other counties	......	159	....	....	....	....	1	....	1,313	4,833	6,146	1 90	11,613 72
Total	13	1,547	7.8	21.7	$3 73	$124,106 61	12	1,010	14,996	59,529	74,525	$2 17	$162,112 71
September													
Bay	5	798	7.9	19.5	$3 63	$57,302 80	5	576	8,060	27,433	35,493	$2 16	$76,776 65
Saginaw	7	737	7.9	23.8	3.85	64,189 45	6	425	3,512	49,705	53,217	1 63	87,247 55
Other counties	......	210	....	....	....	....	1	....	1,215	4,168	5,383	1 87	10,072 00
Total	15	1,745	7.9	21.7	$3 60	$137,192 75	12	1,041	12,787	81,306	94,093	$1 85	$174,096 20
October													
Bay	7	1,092	7.8	13.4	$3 77	$55,615 81	7	510	6,112	30,994	37,106	$2 28	$84,776 32
Saginaw	6	655	7.8	13.6	3 95	35,392 90	6	427	1,758	24,653	26,411	1 91	52,521 08
Other counties	......	182	....	....	....	11,772 00	1	....	825	2,882	3,707	1 93	7,128 90
Total	16	1,929	7.8	13.9	$3 80	$102,360 16	14	967	8,695	58,529	67,224	$2 14	$144,426 30
November													
Bay	4	761	7.6	23.7	$3 53	$63,900 44	4	490	3,289	39,554	42,843	$1 93	$82,897 61
Saginaw	9	1,020	7.9	22.6	4 03	93,958 29	9	973	11,471	62,989	74,460	1 85	138,082 79
Other counties	......	223	....	....	....	20,532 00	1	....	1,244	4,975	6,219	1 96	12,198 24
Total	15	2,004	7.7	23.3	$3 80	$178,390 73	14	1,518	16,004	107,518	123,522	$1 88	$233,178 64
Total for yr.	......	....	....	....	....	$1,548,152 44	....	15,025	130,863	895,352	1,076,215	......	$2,049,811 68
Average	15	1,794	7.9	20.1	$3 57	....	....	1,252	11,071	74,612	....	$1 90	....

*Year ending Nov. 30. Adapted from report of State Coal Mine Inspector, Michigan Department of Labor.

PRODUCTION AND VALUE OF COAL BY COUNTIES.

Year.	Bay.			Eaton.	Jackson.	Saginaw.			Other Counties.†		
	Total coal mined.	Total value.	Average price per ton.	Total coal mined.	Total coal mined.	Total coal mined.	Total value.	Average price per ton.	Total coal mined.	Total value.	Average price per ton.
	Tons.			Tons.	Tons.	Tons.			Tons.		
1899....	104,588	....	....	3,421	21,600	455,607	....	....	....	....	....
1900....	190,814	....	....	4,530	23,317	601,112	....	....	....	....	....
1901....	253,821	....	....	4,803	20,288	938,042	....	....	....	....	....
1902....	248,645	....	....	8,800	23,889	670,304	....	....	....	....	....
1903....	325,021	....	....	7,393	23,307	1,011,898	....	....	....	....	....
1904....	410,634	....	....	9,057	16,860	906,289	....	....	....	....	....
1905....	544,154	....	....	4,058	9,196	915,803	....	....	....	....	....
1906....	481,398	....	....	18,507	8,658	835,475	....	....	....	....	....
1907....	962,574	....	....	5,982	5,645	1,047,927	....	....	....	....	....
1908....	782,503	....	....	2,286	5,539	999,338	....	....	....	....	....
1909....	822,577	....	....	558	1,500	859,434	1,290,933	1.93	101,115	207,545	2.05
1910....	766,470	1,432,293	1.87	100	....	667,282	1,267,652	1.90	90,036	200,825	2.23
1911....	717,084	1,320,484	1.84	1,000	....	667,954	1,267,652	1.90	90,036	200,825	2.23
1912....	630,931	1,237,449	1.96	374	....	504,612	1,025,959	2.03	70,313	136,043	1.92
1913....	591,718	1,176,095	1.99	155	457	596,193	1,194,553	2.00	43,263	84,579	1.93
1914....	617,415	1,215,469	1.97	82	1,287	584,648	1,194,430	2.04	79,598	149,887	1.86
1915....	551,772	1,081,452	1.96	a	a	539,036	1,126,717	2.09	65,330	164,628	2.52
*1916...	495,751	....	....	a	a	526,118	....	....	54,346	....	....

*Compiled from reports of State Coal Mine Inspector, Michigan Dept. Labor. Does not include coal used for steam and heat.
†Includes Calhoun, Eaton, Genesee, Ingham, Jackson, Shiawassee, and Tuscola, except as indicated.
(a) Included under "Other counties."

LIMESTONE.*

The growth of the limestone industry in Michigan was relatively steady from 1899 to 1904 but very rapid from that date to the present. In 1899, the total value of limestone products, including lime was only $281,769, and in 1904, $501,708. Ten years later, in 1914 the value of the products, exclusive of lime, which amounted to $287,648, was $1,457,961 or nearly three times that of both lime and limestone products in 1904. Large increases were made in 1915 and 1916, the total value of all products, except lime being respectively $1,828,766 and $2,389,763. The percentage of gain in 1916 was 30.6 per cent as compared with 25.4 per cent in 1915.

The chief increases were in stone for blast furnace flux, for the manufacture of soda ash and allied products, for concrete and for railway (?) ballast. The production of flux stone in 1910 was only 341,027 tons valued at $186,046 as compared with 2,254,984 tons valued at $763,029 in 1915 and 3,033,155 tons valued at $1,207,326 in 1916. The large increases for 1915 and 1916 in flux stone were due largely to the general industrial prosperity incident to the war and also to the development on a large scale of extensive deposits of very high grade limestone especially adapted for fluxing purposes. This stone is successfully invading the flux stone markets formerly dominated by limestone from other states.

Most of the high calcium limestone is located in Alpena, Presque Isle, Cheboygan, Emmet, and Charlevoix counties in the northern part of the Southern Peninsula and in Schoolcraft, Mackinac, and Chippewa counties in the Northern Peninsula. Important deposits occur at Sibley, Wayne county, and Bellevue, Eaton county. An undeveloped deposit occurs about two miles northeast of Dundee, Monroe county. Small deposits of uncertain commercial importance occur near the mouth of Portage river about six miles north of Jackson, Jackson county, and about three miles northeast of Omer, Arenac county. The reserves of high calcium limestone in the northern part of the state are practically inexhaustible.

Enormous deposits of very pure high magnesian limestone or dolomite occur in the Northern Peninsula near the lake shore from Seul Choix Pt., Schoolcraft county, eastward to Point Detour, Chippewa county. This dolomite is adapted for lining open hearth furnaces and for paper making. Extensive areas of impure limestone suitable for concrete, road material, and ballast occur in the vicinity of the high grade limestone areas in the Northern Peninsula. Low grade magnesian limestone or dolomite occurs in abundance in Monroe and Huron counties.

*For a complete report on the limestone resources of Michigan see Pub. 21, Geol. Ser. 17, Min. Res. of Mich. for 1915, pp. 103-112.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1915.

Year.	Rough building. Value.	Dressed building. Value.	Paving. Value.	Curbing. Value.	Flagging. Value.	Rubble. Value.	Riprap. Value.	Crushed stone. Road making. Tons.	Crushed stone. Road making. Value.
1899	$30,299	*	$62,815				$1,111		
1900	32,362	*	105,266				799		
1901	47,785	*		*	$380	$5,098	*		$31,605
1902	58,707	*		$489	200	3,101	5,740		56,261
1903	36,528	*	49,000	250	5,150	710	800		61,342
1904	32,941	$805	37,665			2,800	2,405		58,655
1905	17,071			160		744	1,568		112,113
1906	9,368	641	90,723	75		4,654	1,204		78,437
1907	15,120	100	56,500			1,433	1,234		131,708
1908	7,276		10,825	300	100	15,907	1,574		182,510
1909	4,450	7,445				1,572	3,615		132,902
1910	3,522		35,500			2,205	908		110,184
1911	7,526					165	380	$224,307	113,574
1912	9,997					380	75	603,553	295,449
1913	8,274					3,511	610	532,311	266,316
1914	3,537					1,651	6,727	505,133	242,839
1915	4,262		*			743	104	482,262	194,970
1916	5,633					*	*	834,215	420,467
Total	$334,658					$41,674	$28,854		$2,489,332

*Included in total for year.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1915.—*Continued.*

Year.	Crushed stone.				For blast furnace flux.		To sugar factories.	To alkali works.
	Railroad ballast.		Concrete.					
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Value.	Value.
1899	....	....	....	....	....	$27,512	....	....
1900	....	....	....	....	....	3,200	....	....
1901	....	$18,200	....	$75,643	....	13,488	....	....
1902	....	40,810	....	49,430	....	32,246	....	....
1903	....	35,340	....	48,504	....	15,502	....	....
1904	....	57,100	....	60,745	....	62,586	....	....
1905	....	43,649	....	107,396	....	109,883	....	....
1906	....	103,442	....	61,852	....	81,517	$224,356	....
1907	....	46,516	....	97,762	....	109,429	22,234	....
1908	....	33,900	....	73,200	....	56,841	32,594	....
1909	....	42,445	....	112,829	....	91,915	25,845	....
1910	....	42,358	....	178,318	....	100,149	69,647	....
1911	91,713	34,998	306,385	137,285	341,027	186,046	65,141	*
1912	54,327	28,368	185,423	97,298	295,941	137,812	36,944	$508,044
1913	116,000	48,400	292,616	145,965	1,202,817	494,495	38,215	320,961
1914	38,000	20,600	362,209	166,959	1,604,240	565,012	69,477	269,087
1915	60,159	19,640	398,948	217,304	2,254,984	763,029	46,143	481,759
1916	186,949	57,950	323,479	155,084	3,033,155	1,207,326	41,709	438,783
Total	....	$671,716	....	$1,785,484	....	$4,057,988	$672,305	$2,018,638

*Concealed—included in total.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1915.—*Concluded.*

Year.	To carbonic acid plants.	To paper mills.	Fertilizer.		Other purposes.	To lime burners.	Rank of state.	Total.
	Value.	Value.	Tons.	Value.			Value.	Value.
1899					$2,375	$157,657		$281,769
1900					124,220	65,000	12	330,847
1901					101,399	136,173	12	429,771
1902					68,164	98,000	13	413,148
1903					4,747	132,600	14	390,473
1904					5,323	180,683	10	501,708
1905					142,790	9,380	12	544,754
1906							10	656,269
1907					278,297		11	760,333
1908					253,990		9	669,017
1909					327,571		11	750,589
1910					299,305		9	842,126
1911		$12,558		$3,003	440,857		8	1,005,751
1912		8,150		3,447	13,596		8	1,139,560
1913		10,723		7,048	395,874		7	1,408,703
1914	$53,138	8,307	10,907	11,104	39,523		8	1,457,961
1915	*	8,620		9,746	31,529		7	1,828,766
1916		11,827		11,088	39,896			2,389,763
Total		$60,185		$45,446	$2,569,456			$15,801,309

*Included in total.

LIME.

From 1904 to 1914 the lime industry in Michigan made no growth, the production being 63,601 tons in 1904, and only 66,359 tons in 1914. In 1915 there was an increase to 81,359 tons but this was 1,749 tons less than the maximum in 1909. In 1916 there was a large decrease to 52,878 tons. This was due largely to the fact that the Charlevoix Rock Products Co. went into the hands of the receivers and ceased operations for the year.

The lack of growth in the lime industry is due to several causes, chief of which are (1) the growing scarcity of suitable cheap wood fuel for burning lime, (2) the substitution of concrete for stone and lime-mortar in construction work, (3) the rapidly growing use of gypsum wall plasters and plaster substitutes, and (4) the unfavorable location of suitable limestone in relation to markets. Formerly, because of the abundance of cheap wood fuel and the difficulty of obtaining lime, lime-burning flourished in many localities in the state, inferior or hard burning limestone often being utilized. The cheapness of good lime, the ease of obtaining it with the development of means of transportation, and the growing scarcity of cheap fuel combined to drive most of the local burners out of business, especially those using inferior or hard burning stone. At present, no lime is produced in the central and southern portions of the state with the exception of a small amount in Arenac county. Lime is burned only at Menominee, Menominee county, Manistique and Marblehead, Schoolcraft county, and Rexton, Mackinac county in the Northern Peninsula and at Alpena, Alpena county, Afton, Cheboygan county, Petoskey and Bay Shore, Emmet county, and near Omer, Arenac county, in the Southern Peninsula.

Most of the exposures are in the northern part of the state relatively distant from ready markets. This makes it difficult for the Michigan burners to compete in the southern more populous portion of the state with lime producers in northern Ohio, Indiana, and Illinois, situated near cheap coal fuel supplies.

Concrete mortar is more easily and rapidly handled than stone and lime mortar and has largely displaced these materials in the building trades. For similar reasons gypsum wall plasters and plaster board have largely displaced sand-lime mortar for plastering.

Much of the lime produced is of the "hot" variety but considerable mild magnesian lime is burned at Manistique, Marblehead, Petoskey and Bay Shore. Hydrated lime is produced at Afton, and Manistique.

The total production in 1916 was 86,477 tons valued at $385,341 as compared with 81,359 tons valued at $349,979 in 1915. This was a net increase of 6.2 per cent in quantity and 10.1 per cent in value. The average price in 1916 was $4.45 per ton or .16 per ton more than in 1915.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1916.

Year.	Total lime burned.		Average price per ton.	No. of plants operating.	Rank of state. Production.
	Quantity, Tons.	Value.			
1904	63,601	$256,955	$4 04	....	....
1905	48,089	192,844	4 01	....	....
1906	68,133	281,465	4 13	13	....
1907	65,822	276,534	4 20	12	16
1908	68,050	282,023	4 14	10	15
1909	83,108	354,135	4 26	12	13
1910	72,345	303,377	4 19	10	14
1911	80,709	352,608	4 37	14	14
1912	74,720	311,448	4 17	11	16
1913	77,088	331,852	4 05	10	14
1914	66,507	287,648	4 33	10	14
1915	81,359	349,979	4 29	10	15
1916	86,447	385,341	4 45	7	....

BRICK AND TILE PRODUCTS.

Raw Materials. Most of the surface clays (see Clay) in Michigan are of low grade and of three general classes, (1) morainic clays or drift clays, (2) lake clays, and (3) river silts. The morainic clays are usually calcareous, containing from 10 to 15 per cent or more of lime. They also contain sand, pebbles, and boulders, hence the name boulder clay. Due to their sandy or calcareous nature, most of the clays are adapted for making only common brick and tile or low grade pottery. The high lime content causes most of the clays to burn white or cream colored. In some places, leaching has removed the lime to the depth of a few feet and clay from this surface portion burns red.

Exposures of clay or shale beds suitable for the manufacture of fire, vitrified, and front brick, vitrified tile, fire-proofing, and other high grade products are not abundant. Near Rockland, Ontonagon county, some of the lake clays belong to the slip varieties and are used for glazing pottery. At Grand Ledge, Eaton county, Jackson, Jackson county, Corunna, Shiawassee county, near Bay City, Bay county and Flushing, Genesee county, shales belonging to the coal measures have been utilized for vitrified and front brick, vitrified tile, sewer pipe, conduits, fireproofing, etc. For the past two years a project for the manufacture of front brick from Coal Measures shales has been under way at Williamston, Ingham county.

The Baker Clay Products Co., at Grand Ledge, has a modern plant equipped with continuous kilns and have begun the manufacture of front brick.

Production. In 1916 the value of brick and tile products in Michigan was $2,705,054, exclusive of pottery, as compared with $2,248,-068 in 1915. This represents an increase of $456,986, or 20.3 per cent. The quantity of common brick increased from 277,399,000 in 1915 to 279,175,000 in 1916, a gain of .6 per cent. The value, however, increased from $1,461,188 in 1915, to $1,856,587 in 1916, an increase of 27 per cent. The average price of common brick in 1916 was $6.65 as compared with $5.23 in 1915, a gain of $1.42. The value of drain tile increased from $305,156 in 1915 to $548,795 in 1916, a gain of $243,639 or 79.7 per cent.

The manufacture of common brick has made great development in the vicinity of Springwells and West Detroit where extensive beds of suitable lake clays occur. The growth of Detroit in this direction, however, has made the land so valuable for building sites that the brick companies are gradually being forced into other localities.

In 1916, of a total of 279,175 common brick, 226,966 were made in Wayne county. Drain tile is next to common brick in importance with a reported value of $28,345. Sewer pipe is manufactured on a large scale at Grand Ledge and Jackson, but there are only two producers, hence no figures of production and value are given. Grand Ledge is also the chief center in the state for the production of vitrified drain tile. The manufacture of front or face brick in Michigan is in its infancy but with two plants in operation, one at Saginaw, Saginaw county, a new one at Grand Ledge, and another projected at Williamston, Ingham county, the production of this type of brick will become of considerable importance. This will meet a great need in the state, for a large amount of face brick is annually imported from Ohio and bordering states.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1916.

Year.	Common brick.		Average price per M.	Front brick.		Average price per M.	Vitrified brick.		Average price per M.	Fire brick.		Average price per M.
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
1899.......	200,144,000	$933,176	$4 66	4,290,000	$58,920	$13 73	*	*	....	....	....	....
1900.......	180,892,000	863,250	4 77	8,421,000	48,411	5 75	*	*	$12 42	....	....	....
1901.......	215,836,000	1,095,254	5 07	9,476,000	64,031	6 76	*	*	12 30	....	....	....
1902.......	237,254,000	1,331,752	5 61	5,684,000	42,792	7 53	*	*	12 26	....	....	....
1903.......	215,791,000	1,251,572	5 80	2,225,000	19,000	8 54	*	*	13 27	....	....	....
1904.......	205,196,000	1,116,714	5 44	1,080,000	7,500	6 94	*	*	13 28	....	....	$13 00
1905.......	211,558,000	1,152,505	5 45	693,000	5,995	8 65	6,112,000	$81,706	13 37	....	....	19 37
1906.......	206,583,000	1,178,202	5 70	1,474,000	14,162	9 61	6,229,000	81,814	13 13	....	....	10 05
1907.......	200,817,000	1,181,015	5 88	3,956,000	32,116	8 12	7,911,000	94,601	11 96	....	....	12 00
1908.......	181,049,000	994,525	5 49	1,896,000	19,496	10 28	6,165,000	76,630	12 43	....	....	....
1909.......	219,820,000	1,250,787	5 69	2,379,000	18,654	7 84	10,473,000	129,283	12 34	....	....	....
1910.......	232,551,000	1,363,316	5 86	2,209,000	27,533	12 46	9,080,000	116,446	12 82	....	....	....
1911.......	252,465,000	1,301,998	5 16	2,498,000	31,572	12 64	5,597,000	78,336	14 00	....	....	18 08
1912.......	271,189,000	1,592,283	5 87	3,934,000	41,476	10 54	6,600,000	92,000	13 94	*	*	17 78
1913.......	273,571,000	1,626,287	5 94	505,000	5,941	1[illegible] 76	8,571,000	126,062	14 71	*	*	16 41
1914.......	269,154,000	1,633,216	6 07	1,488,000	21,1[illegible]1	14 19	7,733,000	120,562	15 59	*	*	19 78
1915.......	277,399,000	1,461,188	5 23	*	*	11 28	*	*	14 50	*	*	....
1916.......	279,175,000	1,856,587	6 65	....	....	....	5,539,000	80,915	14 78	....	....	....
Totals....	4,130,444,000	....	....	....	....	....	....	....	....	....	....	....

*Concealed; less than three producers.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1916.—*Concluded.*

Year.	Stove linings.	Drain tile.	Sewer pipe.	Fire-proofing.	Tile (not drain.)	Miscellaneous.	Hollow building tile or blocks.	Per cent of total product in U. S.	Rank of state.	No. of firms operating.	Total value.
	Value.	Value.	Value.	Value.	Value.	Value.	Value.				
1899	....	$140,171	$50,300	$5,900	....	$22,709	....	1.68	13	196	$1,254,256
1900	....	114,747	57,916	2,350	....	406	....	1.50	17	189	1,147,378
1901	....	98,972	*	1,880	....	637	....	1.71	14	180	1,497,169
1902	....	96,645	*	3,290	....	....	....	1.69	13	182	1,660,942
1903	....	129,028	*	....	....	....	$19,138	1.58	14	178	1,662,414
1904	....	208,088	*	....	....	....	8,080	1.58	14	168	1,670,892
1905	....	205,445	*	*	....	....	3,585	1.41	16	154	1,719,746
1906	....	314,098	*	....	....	....	4,290	1.38	16	142	1,793,367
1907	....	289,868	*	....	....	1,500	6,386	1.39	17	136	1,786,190
1908	....	327,630	*	4,100	....	40,100	....	1.54	16	132	1,666,381
1909	....	364,006	*	*	....	66,128	....	1.44	16	122	1,947,059
1910	....	348,205	*	....	....	*	....	1.53	15	118	2,083,525
1911	$3,971	313,072	*	*	*	228,530	*	1.53	15	111	1,953,442
1912	*	387,945	*	1,461	*	235,459	*	1.73	13	101	2,350,606
1913	....	415,543	*	*	*	350,000	*	1.73	13	95	2,451,242
1914	*	421,941	*	3,752	*	234,280	*	1.88	10	90	2,434,872
1915	....	305,156	*	10,850	*	49,755	*	1.79	11	82	2,248,068
1916	....	548,795	*	2,492	*	216,265	....	....	....	....	2,705,054
Totals	....	$5,029,355	....	....	....	....	....	....	....	....	$34,032,603

*Concealed under miscellaneous; less than three producers.

CLAY.

The clays* of Michigan are of three general classes, viz.: (1) morainic or drift clays (2) lake clays and (3) river silts. Deposits of kaolin or china clays are not known in Michigan and the chances for the occurrence of commercial deposits of such clays appear to be small. Deposits of kaolin have been reported at various places in the Northern Peninsula, but these so far as investigated, have proved to be white or calcareous lake clays of the slip variety. The morainic clays, boulder and till clays, are always calcareous, some of them being very high in lime, especially in limestone regions. In such regions the clays locally approach the nature of impure marls. The lake clays are generally less calcareous but locally, as in limestone regions, they may contain a large percentage of lime. The river silts are the least calcareous but they are usually gritty. On account of the high content of lime, most of the clays burn white. In many beds, however, there is an upper portion relatively free from lime which burns red, and a lower one very high in lime which burns white or cream color. The absence of lime in the upper portion is due to leaching. In such cases, there is usually a zone of lime balls between the leached and unleached portions.

The morainic or drift clays contain pebbles, and boulders (hence the name "boulder clay,") and locally lime concretions. Screening and washing have been resorted to at some plants to separate the clay but the extra expense is generally prohibitive except in districts where good clays are wanting or where the clays possess special burning qualities. The lake clays are comparatively free from pebbles and coarse sand but some contain much very fine grit. These clays are generally suitable for making common brick and tile. There are inexhaustible supplies of such clays in the eastern portion of the Southern Peninsula from Arenac county south to the Ohio boundary. Large areas of lake clays also occur in Chippewa and Ontonagon counties.

The morainic or boulder clays have been developed for the manufacture of common brick and tile at many places in the state but generally on a small scale. The lake clays in the vicinity of Springwells and West Detroit have been developed very extensively for making common brick. With the growth of the city in this direction the land has become so valuable for building sites that the brick industry is being gradually forced into other localities. Important developments have also been made near Paines and West Saginaw, Saginaw county, and at numerous places in Lenawee, Monroe, and Macomb counties.

*H. Reis, Vol. VIII, pt. I, p. 48, Clays and Shales of Michigan, Mich. Geol. Surv.

In Ontonagon county some of the clays are of the slip variety and are suitable for glazing pottery. A deposit of slip clay is also reported near Harriette, Wexford county.

Most of the surface clays in Michigan are low grade and generally the mining of such clays is merely incidental to the manufacturing of common brick and tile. Nearly all of the clay sold as clay in Michigan is slip clay. It is mined chiefly near Rockland, Ontonagon county, and shipped to potteries in Ohio and other states for glazing. The great distance of the beds from the centers of the pottery industry is a serious obstacle in promoting development. In some years, a small amount of clay is sold for medicinal purposes.

PRODUCTION OF CLAY IN MICHIGAN, 1910-1916.

Year.	Slip clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1910...	1,363	$3,889	60	$105	1	$400	1,424	$4,394
1911...	1,744	5,090	18	32	2	150	1,764	5,272
1912...	2,034	6,164	....	....	9	9	2,043	6,173
1913...	1,710	6,504	....	....	....	....	1,710	6,504
1914...	1,463	4,572	....	....	....	....	1,463	4,572
1915...	1,198	3,805	*	*	*	*	3,142	5,605
1916...	....	10,509	....	....	....	....	3,454	11,193
Total..	....	....	....	....	....	....	....	$43,713

*Included in total.

POTTERY.

The pottery industry in Michigan has made almost uninterrupted growth since 1899 and since 1908 the growth has been rapid, particularly in the last three years. In 1899, the total value of the pottery output was $29,741; in 1908, $62,409; in 1910, $112,697; in 1915, $521,989; and in 1916, $792,716. The value in 1916 increased $270,727, or 51.8 per cent. The increase was largely due to the greatly increased output of porcelain and decorated ware and porcelain sanitary and electrical supplies.

The products are chiefly porcelain electrical supplies, decorated and white ware, and flower pots. Of seven firms, three, the Detroit Flower Pot Company, and Anton Hupprich, of Detroit, and the Ionia Pottery Company manufacture flower pots exclusively. The Jeffery-DeWitt Co. of Detroit, manufacture a variety of porcelain products,—sanitary ware, insulators, spark plugs, tumbling jars, crucibles, etc. The Mt. Clemens Pottery Company, Macomb county, manufactures decorated ware and the Pontiac Clay Pipe Novelty Co., Oakland county, clap pipes and novelty ware.

The clays used for the manufacture of flower pots are obtained from Michigan but those for porcelain products, pipes, etc., are imported from other states and countries, for, no deposits of china or ball clays have been found in Michigan.

VALUE OF POTTERY PRODUCTS IN MICHIGAN, 1899-1916.

Year.	Rank of state.	No. firms.	Red earthen-ware. value.	Porcelain electrical supplies. value.	C. C. ware, value.	Miscel-laneous, value.	Total value.	Gain per cent.	Per cent. of total product in U. S.
1899	18	4	$29,641		$100		$29,741		.17
1900	17	4	34,317				34,317	15.4	.17
1901	16	5	42,465			$2,400	44,865	30.2	.20
1902	14	4	44,098			39,000	83,098	87.4	.41
1903	19	4	42,007			6,000	48,007	-42.2	.19
1904	17	4	40,621			3,000	43,621	-9.1	.17
1905	17	5	*		*	7,000	45,961	4.5	.16
1906	17	6	43,510			7,600	51,110	11.2	.16
1907	16	6	54,474			7,100	61,574	18.5	.20
1908	16	6	54,659			7,750	62,409	1.5	.25
1909	13	5	60,939			34,500	95,139	52.9	.31
1910	13	6	94,450	*		13,300	112,697	18.1	.33
1911	13	6	80,580	*	*	*	130,490	15.8	.38
1912	10	6	99,555	*		*	194,892	49.3	.53
1913	10	5	65,000	*		*	222,133	20.8	.59
1914	9	5	106,452	*	*	*	265,194	33.0	.75
1915	8	6	112,863	*	*	*	521,989	96.7	1.40
1916	8	7	123,734	†	†	668,982	792,716	51.8	1.64
Totals							$2,840,253		

*Included in the total.
†Included under miscellaneous.

SAND-LIME BRICK.

The first sand-lime brick plant in the United States was started at Michigan City, Indiana in 1901. The sand-lime brick industry was a "boom" industry and within two years nine plants were in operation, in the process of building, or projected. Under the erroneous impression that sand-lime brick, satisfactory for most purposes could be made much more cheaply than ordinary clay brick, many plants were erected all over the country without proper investigation of marketing conditions, transportation facilities, competition from clay brick or of the character and supply of the raw materials, and methods of manufacture. The industry suffered from the resulting failures and especially from the generally poor character of the product.

The sand-lime brick industry is more adapted to regions where good brick clays are scarce and sand abundant, but for ordinary building purposes, sand-lime brick, where properly made, is now successfully meeting competition from clay brick, in the face of a more or less general prejudice on the part of contractors against sand-lime brick.

Fortunately in Michigan most of the early plants were started in widely separated regions, and for from large clay working industries or were located near large cities which afforded a ready market for a limited production. The industry therefore did not suffer from as large a proportion of failures as in some of the other states and has maintained a relatively steady growth.

Michigan quickly attained first rank as a producer of sand-lime brick, which rank she has held since 1904, with the exception of one year.

The growth has been in increased production rather than in number of plants. In 1904, ten plants were in operation and produced only 10,440,000 brick of all grades, valued $69,765. In 1905, twelve plants were in operation and produced a total of 26,421,000 brick valued at $169,302. Since 1905, the number of operating plants has remained about the same, fluctuating between 10 and 13, but the production and value have greatly increased. The number of operating plants in 1916 was the same as in 1905 but the production was 72,004,000 brick of all grades, valued at $499,711, or about two and three-fourths times the number and nearly three times the value in 1905. This is the maximum in the history of the industry and represents an increase over 1915 of 52.3 per cent in quantity and 74.1 per cent in value. The average price of common brick in 1916 was $6.92 per thousand as compared with $6.04 per thousand in 1915.

General conditions were evidently much improved over 1915, for out of twelve operators, ten reported much better demand and higher prices, one, trade conditions about the same, and one, poorer trade. Labor scarcity was reported by two operators.

The production of front and fancy brick has fluctuated greatly. The production of front brick increased from 580,000 in 1904, to about 2,000,000 in 1907, then decreased the following year to about 900,000. The maximum production of 3,255,000 was reached in 1910. Since 1911 the production of front brick has not exceeded 1,000,000 per year. It appears that front and fancy sand-lime brick as manufactured are not as satisfactory for outside work, or cannot be produced as cheaply as clay front brick.

Since 1904, Michigan has held first rank among the states both in number of operating plants and value of output, with the exception of 1906 when New York took first place. For a number of years, Michigan has produced nearly twice or more than twice as many sand-lime brick as any other state and in 1916 produced one-third of the total value for the United States. In 1916, twelve plants were in operation in Michigan, whereas Florida and Minnesota, the nearest competitors, each possessed four plants. In 1916 a new plant replacing the plant of the Fairview Brick Company, of Detroit, which was burned in 1915, was put in operation by Flood and Hall at Fairview, a suburb of Detroit. Two plants are located at Detroit and one each at Flint, Grand Rapids, Kalamazoo, Menominee, Ripley (Houghton County), Rives Junction (Jackson County), Rochester (Oakland County), Saginaw, Sebewaing (Huron County), and Sibley (Wayne County).

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1916.

Year.	No. of operating firms reporting.—Mich.	No. of operating firms reporting.—U. S.	Michigan production. Common brick. Quantity, (thousands).	Common brick. Value.	Average price per thousand.	Front brick. Quantity, (thousands).	Front brick. Value.	Average price per thousand.	Fancy brick. Quantity, (thousands).	Fancy brick. Value.	Total value Michigan.	Change per cent.—Michigan.	Total value United States.	Per cent of total production of U. S.	Rank. Production.	Rank. Value.
1904...	10	57	9,886	$64,034	$6 64	580	$5,234	$9 02	19	$497	$69,765	....	$463,128	15.6	1	1
1905...	12	84	24,841	155,883	6 28	1,577	12,893	8 17	24	526	169,302	142.7	972,064	17.4	1	1
1906...	11	87	27,281	162,879	5 97	1,796	12,022	6 69	7	20	174,921	3.3	1,170,005	15.0	1	2
1907...	13	94	25,488	158,606	6 22	*2,000	14,234	7 17	......	......	172,840	-1.2	1,225,769	14.1	1	1
1908...	10	87	21,997	131,827	5 99	*900	6,982	7 76	......	......	138,809	-19.7	1,029,699	13.5	1	1
1909...	11	74	34,217	207,082	6 05	*1,600	11,144	6 97	......	......	218,226	57.2	1,150,580	19.0	1	1
1910...	10	76	37,648	218,627	5 81	3,256	22,022	6 76	......	......	240,649	10.3	1,169,153	20.5	1	1
1911...	10	66	32,889	192,224	5 84	2,726	17,777	6 52	......	......	210,001	-12.7	897,664	23.4	1	1
1912...	11	71	48,129	307,106	6 38	1,163	9,626	8 27	......	......	316,732	50.8	1,200,223	26.4	1	1
1913...	12	68	49,373	315,882	6 40	†	†	......	†	†	321,245	1.7	1,238,325	25.9	1	1
1914...	12	62	41,456	248,113	5 98	†	†	......	†	†	255,784	-24.4	1,058,512	23.5	1	1
1915...	11	56	46,513	281,009	6 04	†	†	......	†	†	286,948	11.8	1,135,104	25.3	1	1
1916...	12	53	71,116	491,866	6 92	888	7,845	8 83	......	......	499,711	74.14	1,474,073	33.8	1	1
Total..	....	....	470,834	$2,935,138	$6 23	....	....	......	......	......	$3,074,933	....	....	....	......	......

*Estimated. †Included in total.

SANDSTONE.

For many years before the close of the last century the quarrying of sandstone was an important industry in Michigan. There were numerous quarries, though generally small, in Hillsdale, Jackson, Calhoun, Ionia, Eaton and Huron counties. No records, however, were kept until near the close of the century. In 1899, the production was valued at $178,038, the largest recorded, except in 1902, when the value of the output was $188,073. A rapid decline, though intermittent at first, began in 1900, and continued until 1911, when the industry all but ceased, the value of the output being only $12,985. For the past three years there have been only one or two producers, hence no figures have been given.

The decline of the sandstone industry in Michigan may be ascribed to (1) the poor quality of much of the sandstone, (2) the substitution of concrete in construction work and (3) the greater use of brick and artificial stone.

Quarries formerly were operated in the sandstone of the Coal Measures near Ionia and at other places in Ionia county, and at Grand Ledge, Eaton county; and at many places in the Marshall sandstone in Calhoun, Hillsdale, Jackson, and Huron counties. Most of the sandstone in these formations upon exposure to the weather for a few years, alters more or less uniformly or in spots and streaks to an unsightly yellow color. This is due to the fact that the cementing material, especially in the Marshall, contains a considerable amount of iron carbonate, which upon exposure to the weather is oxidized to limonite. The sandstone near Ionia, though soft and friable is streaked and mottled with red, orange, and yellow and makes a pleasing appearance in buildings. Some of the stone when first quarried is reported to be so soft that great care must be used in handling to prevent breakage. After seasoning for some time, the stone becomes sufficiently hard to work and strong enough for ordinary building purposes. The only quarries operating in the Marshall at the present time are at Grindstone City and Eagle Mills, Huron county, where the gritstones near the base of the formation are quarried for grindstones and scythestones. Some rubble and riprap are produced incidentally to the quarrying of gritstone, at Eagle Mills by the Wallace Company of Port Austin.

The only quarry producing sawed and rough building block is near Jacobsville, Houghton county. Extensive quarrying operations have been carried on near Portage Entry for many years but now the Portage Entry Redstone Co. is the only active operator. The sandstone is known as the Jacobsville and is apparently the equivalent of the Lake Superior or Upper Cambrian sandstone. The "redstone" or "brownstone" of the Jacobsville is well cemented, permanent in color and pleasing in appearance, but the great distance from markets is a serious obstacle to development.

Formerly much sandstone was quarried for foundations but concrete has largely displaced stone for such purposes because of the cheapness of concrete and the rapidity and the ease of handling. Front and fancy brick are relatively cheap and a variety of artistic effects are possible through their use. Because of this they have largely displaced stone as a building material, except for foundations.

Artificial stone is now displacing natural stone for these, especially for outside work.

Apparently the sandstone industry will not soon regain its former importance.

*PRODUCTION AND VALUE OF SANDSTONE IN MICHIGAN, 1899-1916.

Year.	Rough building. Value.	Dressed building. Value.	Curbing. Value.	Flagging. Value.	Rubble. Value.	Riprap. Value.	Crushed stone. Road making. Value.	Crushed stone. Concrete. Value.	Other. Value.	Total. Value.
1899	$102,447	$51,682	$109	a	....	....	....	....	$23,800	$178,038
1900	73,850	58,800	....	....	....	....	....	....	....	132,650
1901	128,909	....	....	....	$26,519	b	....	....	19,000	174,428
1902	136,280	23,600	....	....	27,393	$800	....	....	....	188,073
1903	89,931	10,365	....	....	15,554	....	$2,050	$3,450	....	121,350
1904	47,593	14,818	....	....	10,657	....	1,400	400	....	74,868
1905	64,056	36,035	....	....	10,332	....	....	....	12,700	123,123
1906	35,272	18,950	....	....	10,403	770	....	....	....	65,395
1907	33,561	10,918	....	$528	7,900	96	....	....	....	53,003
1908	15,100	18,813	....	....	5,190	....	....	....	....	39,103
1909	12,985	16,805	....	....	6,294	....	....	....	....	36,084
1910	13,312	15,416	....	....	2,505	....	....	....	....	31,233
1911	5,682	2,809	....	....	3,068	1,140	....	....	286	12,985
1912	c	c	....	....	c	c	....	....	a	16,438
1913	c	c	....	....	c	3,127	....	....	c	19,224
1914	d	d	....	....	d	d	....	....	....	d
1915	d	d	....	....	d	d	....	....	....	d
1916	d	d	....	....	d	d	....	....	....	d
Totals	....	....	$109	....	....	....	....	$3,850	....	....

a Included under curbing.
b Included under rubble.
c Included in total.
d Figures not given—less than three operators.
*Exclusive of sandstone made into grindstones and scythestones.

GRINDSTONES AND SCYTHESTONES.

Although Michigan ranks second to Ohio in the production of grindstones and scythestones, the latter state produces about eight times as much as Michigan. The "grit" or "grindstone" occurs in the lower part of the Marshall formation in Huron county. The Wallace Company of Port Austin and the Cleveland Stone Company operate quarries at Eagle Mills and Grindstone City respecttively where the gritstone occurs in low-lying and thinly drift covered ledges near the shore of Lake Huron. The surface deposits are removed by stripping, and the stone is cut by channelling machines into square blocks eight feet or more in thickness. These are split with wedges along the bedding planes into thinner slabs which are loaded on cars by derricks, then carried to the mills for sawing into grindstones. The grindstones vary in size from very small ones a foot in diameter up to those seven feet in diameter with a 14-inch face. The broken stone is made into various grades of scythestones.

As there are but two producers no tables of production and value can be given.

SAND AND GRAVEL.

Michigan has very large sand and gravel resources. The most important deposits occur in the form of ridges known as "hogbacks" or eskers, in irregular hills, called kames, in out-wash plains and deltas, and in old beach ridges, features resulting from the last glacial invasion. Only a small portion of the sand and gravel resources have been developed. The chief developments are in the southern half of the Southern Peninsula and in the vicinity of cities, in river channels, and along the shores of the Great Lakes where means of transportation are favorable. Large pits are locally developed in building state award roads. The chief localities and counties in order of importance are: Detroit and St. Clair rivers and Kent, Washtenaw, Macomb, Ingham, Livingston, Manistee, Oakland, Berrien, Jackson, Kalamazoo, and Calhoun counties.

In 1916 Michigan produced 4,407,475 tons of sand and gravel valued at $1,295,717. This represents a gain of 630,749 tons or 16.7 per cent in quantity, or 24.9 per cent in value. The chief increases in quantity were in moulding sand, building sand and gravel. There were but two producers of glass sand (See Glass-Sand) in 1915, hence figures of production and value are not given.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1904-1916.

Year.	Glass sand.		Molding sand.		Building sand.		Fire sand.		Engine sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.	
1904	......	......	167,147	$76,299	69,656	$30,898	.....	......	....	....
1905	......	......	19,382	13,247	263,315	148,065	5,000	$2,500	....	....
1906	600	$3,000	61,387	26,108	403,199	127,937	.....	......	4,000	$400
1907	4,300	8,600	54,172	24,190	451,646	157,150	6,000	3,000	1,534	153
1908	17,000	34,000	4,584	2,892	474,238	228,395	.....	......	1,991	319
1909	65,000	79,000	53,226	20,756	1,090,419	327,247	4,000	2,000	12,415	1,493
1910	16,212	25,675	93,812	24,004	1,151,588	334,336	5,000	3,000	22,270	2,172
1911	*	*	68,878	17,901	833,729	247,997	*	*	25,392	4,447
1912	*	*	152,433	40,145	902,556	294,115	.....	......	18,575	4,774
1913	*	*	50,763	17,493	1,326,016	415,737	4,542	4,542	4,447	647
1914	26,035	32,593	53,400	36,583	1,088,650	360,152	.....	......	6,357	1,066
1915	*	*	82,666	25,998	843,887	236,956	4,601	5,751	70,077	2,794
1916	*	*	117,200	31,978	1,234,280	350,138	*	*	*	*
Totals.	......	......	979,051	$357,595	10,133,179	$3,269,123	.....	......	167,058	$18,265

Year.	Furnace sand.		Paving sand.		Other sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.	
1904	....	....	....	....	....	....
1905	....	....	....	....	50,187	$14,476
1906	5,000	$2,500	....	....	51,005	12,140
1907	3,858	3,133	....	....	173,724	12,187
1908	3,329	3,828	....	....	29,187	6,850
1909	3,183	3,660	....	....	295,612	50,953
1910	3,185	4,924	....	....	372,880	57,385
1911	*	*	152,144	$29,650	114,801	52,005
1912	....	....	68,453	16,898	130,624	54,746
1913	†	†	533,261	108,328	113,318	20,342
1914	†	†	320,322	74,866	115,291	107,392
1915	....	....	131,466	14,021	111,105	12,248
1916	*	*	154,413	38,068	228,003	103,722
Totals	....	....	1,360,059	$287,831	....	....

Year.	Railroad ballast.		Gravel.		Total.		Rank.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1904	....	....	....	....	236,803	$107,197	....	....
1905	....	....	76,625	$32,321	414,509	210,609	10	11
1906	....	....	72,598	25,614	597,789	197,699	12	13
1907	....	....	329,407	81,182	1,024,641	289,595	10	11
1908	....	....	312,262	94,081	842,591	370,365	8	9
1909	....	....	695,902	200,523	2,219,757	685,632	8	8
1910	....	....	1,197,791	364,841	2,862,738	816,337	7	8
1911	....	....	935,072	203,218	2,185,165	565,969	9	10
1912	....	....	1,409,180	407,925	2,681,821	818,603	9	8
1913	....	....	3,928,874	915,205	6,422,818	1,528,892	4	5
1914	7,565	$781	2,140,359	530,338	3,757,979	1,143,771	8	7
1915	....	....	2,457,094	671,970	3,776,726	1,036,739	....	....
1916	....	....	2,226,878	726,033	4,407,475	1,295,717	....	....
Totals	....	....	15,782,042	$4,298,251	31,530,812	$9,067,125	....	....

*Included under other sand. †Included under fire sand.

GLASS SAND.

Glass sand is extensively quarried near Rockwood, Wayne county and near Steiner, Monroe county. The glass sand rock occurs in the Sylvania sandstone or Middle Monroe of the Silurian. The Sylvania underlies a belt extending west from the mouth of Detroit river, then curving to the southwest across the southeast corner of Wayne county and through Monroe county, leaving it near the southwest corner. The belt is from three to five miles wide except in the southwest corner of Monroe county where it narrows to about one-half mile. The Sylvania is exceedingly variable in thickness. In Wayne county, along Detroit river it is from 70 to 165 feet in thickness and here as elsewhere contains horizons of sandy dolomite. To the southwest it thins irregularly until near the Ohio line it is about 35 feet thick.

The sandstone is exposed or is near the surface in three localities, viz.: in the southwestern part of Whiteford township (T. 8 S., R. 6 E.) and in the vicinity of Steiner, Monroe county, and Rockwood, Wayne county. In section 28 of the Whiteford township area the overburden is locally ten feet or less in depth. It is exposed for a considerable distance in the bed of Raisin river near Steiner in the southwest quarter of sec. 2, T. 6 S., R. 8 E. At this place the rock is exposed* or covered by a few inches of soil on an area of 8 to 10 acres and on an area of 60 acres the overburden is reported to be nowhere more than two or three feet thick.

There are no natural exposures of the Sylvania in Wayne county but east of Rockwood in section 16, in the vicinity of the pits of the American Silica Company, the overburden is only from five to eight feet deep. Apparently there is an area of several hundred acres in the vicinity of Rockwood where the overburden does not exceed twenty feet.

Typically the sandstone is a remarkably pure, sparkling, snow-white aggregation of fine incoherent quartz grains of very uniform size and resembling granulated sugar. Lumps of it may be readily crumbled in the hands and when placed in water they literally fall to pieces. At the pits of the American Silica Co. east of Rockwood, Wayne county and of the National Silica Co. near Steiner, Monroe county, the sandstone is washed down by a small stream of water from a hose. At the Rockwood pit there is a stratum of hard dolomitic sandstone which requires blasting. The material after being crushed and washed is pumped into bins where it is allowed to drain.

Some years ago the Rockwood Silica Sand Co. drilled a well just

*W. H. Sherzer, Vol. VII, pt. 1, p. 54, Geology of Monroe County, Mich. Geol. Surv.

east of Rockwood (SE ¼ SW ¼, Sec. 10) to the depth of 122 feet penetrating 15 feet of clay, 15 feet of dolomite, and 92 feet of glass sand rock without reaching the bottom of it. A six-inch casing was used to rock and below this a four-inch casing, through which steam under a pressure of 60 pounds per square inch was injected, forcing out water and sand. About a car-load of sand per day was obtained in this way.

Glass sand pits known at "Tolls Pits" were opened many years ago near Steiner, Monroe county. These properties later were taken over by the National Silica Co. which operated them up to 1916 when its plant was burned down. The property has been recently sold to the Ford Plate Glass Co. of Toledo, Ohio. The Whiteford area is undeveloped.

Immediately beneath the drift, the sandstone is more or less colored to a depth varying from a few inches to several feet, by iron from percolating surface waters. Elsewhere the sandstone is remarkably free from iron. In the pit of the American Silica Co. at Rockwood, there are numerous masses of celestite, or strontium sulphate, and native sulphur. The masses appear to be most numerous near the horizon of dolomitic sandstone. Washing removes practically all of the small amount of dolomitic cement in the incoherent sandstone, and most of it from the dolomitic sandstone. The sand as marketed is said to average over 99 per cent silica and is adapted for making the highest grades of glass.

The following analyses are of the crude unwashed sand from the pits of the National Silica Co. at Steiner, Monroe county, and of the washed product from the pit of the American Silica Co. at Rockwood, Wayne county.

ANALYSIS OF GLASS SAND.

	Crude Percent.	*Washed Percent.
Silica	96.50	99.70
Calcium carbonate	1.50	0.08
Magnesium carbonate	1.04	0.22
Iron oxide	0.00	....
Surphuric acid loss and undetermined	0.76	....
Loss on ignition	0.20	....

A large amount of glass sand is produced from these pits and sold to plate glass factories in Michigan, Ohio, and other states. The washed sludge containing the fine grit is used for the ignition sur-

*Analyst Dr. J. E. Clark, Detroit.

face on match boxes. Since there are but two producers, no figures of production can be given, the output being included in the state totals of sand and gravel.

NATURAL GAS.

In Michigan natural gas* is obtained both from the drift and from the underlying bed rocks. The supply in Macomb and Oakland counties is entirely from the drift, but in St. Clair county it is chiefly from the oil wells (See Petroleum), where it occurs in association with the oil. Gas also occurs in considerable quantities in the drift around Portage Lake, Manistee county, and in Alcona and Montmorency counties.

The surface gas is most abundant in the belts underlain by the bituminous and petroliferous Devonian formations and presumably is the result of leakage from these formations. At many places in these belts, gas is given off in springs and shallow wells, sufficient in some cases to be lighted. Many explorations have been made upon the basis of such evidence but no gas of commercial importance was found in any of the borings. In general such signs are of little significance in Michigan, particularly as they are most frequent along the line of exposures of the oil and gas bearing formations, therefore are in the zone of leakage, rather than accumulation.

The gas generally occurs in small volume and under low pressure, the pressure generally varying from a few pounds to forty pounds or more. Most of the wells yield gas sufficient only for the needs of a family or two. Generally they last for a number of years but some of them "play out" in a few days or weeks. In Oakland and Macomb counties, 25 or 30 drift gas wells are or have been utilized by farmers for heating and lighting purposes. According to the reports of the owners many of the wells have been declining rapidly in pressure and volume during the past three years.

Many artesian wells around Portage Lake, Manistee county, yield some gas. In 1913 gas was struck in a well in drift west of Onekama near the shore of the lake. The gas was under a pressure of about 190 pounds per square inch. At last reports, the gas from only a few of the wells has been utilized. Small drift gas wells also occur and are utilized to a limited extent in Benzie, Monroe, and Washtenaw counties.

At Port Huron, some of the May and Gillette oil wells about two miles west of Port Huron are reported to yield from 20,000 to 40,000 cubic feet per day, when allowed to flow freely. The gas pressure is said to vary from 125 to over 250 pounds per square inch. In 1915,

*Pub. 14, Geol. Ser. 11, Occurrence of Oil and Gas in Michigan, 1912.

a project was under way for utilizing the excess gas for lighting a small suburb of Port Huron, but apparently nothing came of it. Several other wells drilled for oil in various parts of the city yield sufficient gas to be utilized for domestic and industrial purposes.

At Mt. Clemens, some of the wells, from which the mineral water for the bathing establishments is obtained, also yield gas nearly sufficient for heating the boilers used for pumping.

The total production of natural gas in the state however, is relatively insignificant, the average value for the past six years being less than $1,500 annually.

PRODUCTION OF NATURAL GAS IN MICHIGAN, 1911-1916.

Year.	No. of producers.	Domestic.		Industrial.		Other.		Total.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		M. cu. ft.		M. cu. ft.		M. cu. ft.		M. cu. ft.	
1911...	22	930	$930	....	....	800	$400	1,730	$1,330
1912...	17	....	1,020	900	$450	....	....	900	1,470
1913...	....	....	....	....	....	....	....	1,805	1,405
1914...	....	....	....	....	....	....	....	2,442	1,442
1915...	16	960	960	....	....	1,100	550	2,060	1,510
1916...	12	598	598	....	....	700	350	1,298	948
Total..	....	....	....	....	....	....	....	....	....

PETROLEUM.

Oil* has been found in small quantities at many places in Michigan, notably at Port Huron, Allegan, and Saginaw. At Port Huron† there are two principal groups of productive wells and several scattered wells. All of the wells are very small, the average yield per day probably being about one-half barrel. Some of the wells when first drilled are said to have yielded as much as seven barrels per day, but the production gradually fell off to less than a barrel. Most of the wells yield gas and some of them, considerable quantities. Their shallow depth, 500 to 600 feet, and the presence of sufficient gas for motive power in pumping the wells and drilling new ones, make possible profitable operation. The G. B. Stock Xylite Grease and Oil Company operates a group of eighteen wells and uses the oil in the manufacture of lubricants for which it is adapted. A group of eleven wells has been drilled on the Henry May and Lawrence Gillette farms near the "Oxbow" bend of Black

*Pub. 14, Geol. Ser. 11, Occurrence in Oil and Gas in Michigan, 1912.

†See Publication 19, Geol. Ser. 16, Mineral Resources of Michigan for 1914 for a more complete discussion of the Port Huron field.

River about two miles west of North Port Huron. Drilling is now (June, 1917) in progress on the Henry May farm. The average yield of oil from these wells, when pumped, is said to be similar to that of the Stock wells. It is probable that a few more small wells will be sufficient to make the operation of this group profitable, especially as some of the wells yield significant quantities of gas, more than sufficient to furnish power for operating the wells and drilling new ones.

There was but one operator reporting a production in 1916, hence figures of production and value are omitted.

MINERAL AND SPRING WATERS.

There has been a persistent decline of the mineral water industry in Michigan since 1902, though the amount and value of mineral and spring waters produced in Michigan fluctuate greatly from year to year.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900-1916.

Year.	Rank.		No. of Springs active.	Total.		Medicinal. Value.	Table. Value.	Average price per gal.
	Quantity.	Value.		Quantity. Gals.	Value.			
1900	6	4	28	3,398,996	$411,935	....	....	$0.121
1901	2	1	28	7,019,168	1,195,614	....	....	0.170
1902	1	9	28	8,653,690	275,763	....	....	0.032
1903	1	9	19	6,919,107	200,668	....	....	0.029
1904	7	13	19	3,385,675	118,422	....	....	0.035
1905	4	4	17	2,684,800	277,188	$38,900	$238,288	0.100
1906	13	23	19	902,528	73,357	....	....	0.081
1907	8	15	19	1,472,679	127,133	35,091	92,042	0.086
1908	8	16	24	2,004,433	88,910	5,995	82,915	0.044
1909	5	16	19	2,760,604	104,454	6,099	98,355	0.035
1910	9	17	17	1,454,020	69,538	100	69,438	0.048
1911	11	24	23	1,713,401	72,253	12,156	60,097	0.042
1912	12	19	17	1,420,465	75,611	777	74,834	0.053
1913	17	24	20	884,893	52,642	3,605	49,037	0.059
1914	16	20	22	931,343	70,310	12,252	58,058	0.075
1915	16	18	19	913,765	72,711	5,165	67,546	0.080
1916	......	......	18	996,875	108,867	....	....	0.109
Total	......	......	......	47,516,442	$3,397,376	$114,140	$890,610	$0.09

The principal factors affecting the production are (1) general business conditions, (2) local conditions affecting municipal supplies. The largest decreases in production in Michigan occurred in the general business depressions of 1906, and 1907, and of 1914. The municipal water supplies in certain cities are unsafe or unpalatable and consequently a thriving business of vending spring waters has grown up in these cities. During the past few years, the quality of the supplies in some of these cities has been greatly improved through the installation of filtration plants or the development of new sources. The production in 1902 was 8,653,690 gallons valued at $275,763. In 1916 only 996,875 gallons, valued at $108,867, were produced, as compared with 913,765 gallons valued at $72,711 in 1915. This was a gain of 83,110 gallons and $36,156 or .091 per cent in quantity and 50 per cent in value. The large gain in value was due chiefly to the larger average price which was 10.9 cents per gallon as compared with 8 cents in 1915.

MARBLE.

The Kona dolomite in the Marquette iron bearing district, the Randville dolomite in the Menominee and Crystal Falls districts locally have been more or less completely metamorphosed into dolomitic marble. The marble varies in texture from coarse to fine, and in color from white to various tones of pink, blue, green, and brown. The marble generally contains so much interbedded impurities such as slate and quartzite, or grades into these rocks, that few of the deposits offer commercial possibilities. Attempts have been made to quarry the marble in several places, but according to reports the large amount of waste made operations unprofitable. An old marble quarry in Sec. 26 T. 42 N., R. 28 W., Dickinson county, is now operated for the manufacture of whiting and paint filler.

Verde Antique Marble. A belt of altered peridotitic rocks about 4½ miles in length occurs northwest of Ishpeming, Marquette county. These rocks have been altered largely to serpentine and dolomite, or so-called *verde antique marble.* In some places the rock is almost wholly dolomite but generally it is a dolomitic serpentine, the dolomite investing the rock by an intricate system of veins and stringers of dolomite. The serpentine varies from light to dark green with tones of olive, but the dolomite is generally white. The rock takes a high polish and the intricate veining produces very beautiful effects. Polished slabs exhibited in the office of the Survey indicate that the stone, locally at least, is equal or superior to much of the verde antique now on the market.

For the past two years the Michigan Verde Antique Marble Co. of Ishpeming has been opening a quarry about five miles northwest of the city in section 30, T. 48 N., R. 27 W., and began limited shipments early in 1917. The marble was hauled in winter on sleds to the railroad, pending the building of a railroad spur. The Marquette Green Marble Co. made an attempt to open a quarry east of the old Michigan gold mine but become financially involved and suspended operations in the summer of 1917.

Apparently there is a large amount of easily available *verde an-*

tique marble in the belt, and with careful development, the marble industry in this district probably will become of considerable or even large importance.

SHALE.

Shale is quarried near Coldwater, Branch county, at Paxton, Alpena county, one mile south of Ellsworth, Antrim county, and at Bellevue, Eaton county for use in the manufacture of Portland cement; at Grand Ledge, Eaton county, for vitrified sewer-pipe, tile and conduit and front brick; six miles north of Jackson near the mouth of Portage River, Jackson county, for vitrified sewer-pipe and tile; at Flushing, Genesee county, and near Corunna, Shiawassee county, for vitrified brick.

The Michigan Vitrified Brick Company of Bay City formerly mined shale from an abandoned coal mine for the manufacture of vitrified brick but this company ceased operating in 1916.

For the past two years a project has been under way to develop shale beds at Williamston for the manufacture of front brick. Although a large area of shale land was explored and burning tests were made of the shale, the project has not materialized.

The shale beds at Grand Ledge, Jackson, Flushing and Corunna belong to the Coal Measures. The beds vary from soft white, or light gray clay shale to compact, dark or black bituminous shale. Probably further tests will show that some of the beds are suitable for other products than those now made. The beds at Paxton belong to the lower portion of the Antrim formation of the Upper Devonian. The extent of the easily quarryable shale near Paxton is unknown but propably exploration would reveal the presence of a number of quarryable areas. Most of the shale exposed is dark brown and very bituminous but locally there are streaks of bluish to greenish gray shale and huge balls of iron carbonate and dolomite. The shale beds at Ellsworth belong to the upper part of the Antrim and are largely of soft blue gritless shale, with a few thin dark bituminous beds. The extent of the easily quarryable areas is uncertain but apparently large. Tests probably will show that this shale is suitable for a variety of purposes. Other exposures of the Antrim shale occur in Charlevoix, Cheboygan, and Alpena counties, notably along the shore of Lake Michigan at Norwood, Charlevoix county.

Excellent exposures of shale belonging to the Coldwater formation occur at Richmondville, Sanilac county, and along the shore of Lake Huron from Forestville in the same county to Whiterock, Huron county. The Coldwater shale is also exposed or is at shallow depth in a number of places in the vicinity of Coldwater, Union City, Quincy, and Bronson, Branch county, but it is utilized only at Coldwater.

Exposures of the Bell shale, the base of the Traverse formation, occur near Bell, Presque Isle county. At Rockport, Alpena county, it forms the floor of the quarry of the Great Lakes Stone & Lime Company. The shale is soft, bluish, and generally highly calcareous. Probably most of it will be found suitable for use in the manufacture of Portland cement. At Charlevoix, a bed of shale about 10 feet thick occurring in the upper Traverse limestones, forms the floor of the quarry of the Charlevoix Rock Products Company. This shale is reported to have been tested and found suitable for the manufacture of vitrified products.

Unfortunately most of the deposits of good shale occur in the northern part of the Southern Peninsula, far from large markets, or at some distance from means of cheap transportation.

SLATE.*

Extensive deposits of black slate suitable for roofing occur in Baraga county chiefly on the northwest side of Huron Mountains in the vicinity of Huron Bay. From 1875 to 1878 and 1883 to 1888 slate was quarried in a number of quarries at Arvon. All of the attempts to develop the slate industry in the state failed chiefly because of the poor methods of quarrying, though many natural difficulties were important contributing factors. The slate at Arvon is of fine texture, pleasing black color, and uniform quality and compares favorably with the product from eastern quarries.

TRAP ROCK.

There are inexhaustible resources of trap rock in the western half of the Northern Peninsula, chiefly in the iron and copper bearing districts. Trap rock is quarried at Marquette and Negaunee, Marquette county. Large quantities of amygdaloidal trap are produced incidentally to the mining of copper. The trap rock from Marquette county is harder, tougher, and less altered than that from the copper mines. The inferior wearing qualities of the amygdaloidal trap, however, is partially compensated by superior cementing power.

Most of the quarry product is crushed for road material and concrete. In some years, a small amount has been sold for rip-rap. The great distance from markets is a serious obstacle to the development of the trap rock industry of the state.

*For a more complete report see Pub. 16, Min. Res. of Mich. for 1913, pp. 92-95, Mich. Geol. & Biol. Surv.

PRODUCTION AND VALUE OF TRAP ROCK IN MICHIGAN, 1911-1916.

Year.	No. of producers.	Crushed stone.				Riprap. Rubble. Value.	Total. Value.	Rank. Value.
		Road making.		Concrete.				
		Quantity.	Value.	Quantity.	Value.			
		Tons.		Tons.				
1911...	3	....	....	45,250	$38,429	....	$51,000	8
1912...	5	21,805	$18,366	11,355	9,340	$8,500	36,206	8
1913...	5	24,920	23,369	*	*	*	92,201	10
1914...	5	25,690	24,863	4,448	4,771	....	34,406	12
1915...	6	28,262	29,764	18,775	22,047	*	105,855	12
1916...	....	38,193	37,475	9,601	9,715	....	83,072	....
Total...	....	138,870	$133,837	....	....	....	$402,440	....

*Included in total.

GRAPHITE.

Graphite slate occurs southeast of L'Ansé, Baraga county. Quarries have been opened about 9 miles southeast of L'Anse by the Detroit Graphite Company, Detroit, and by the Northern Graphite Company of L'Anse. The graphite material is ground for paint.

The quarries are operated only intermittently, enough material being taken out in one year to supply the needs of the companies for a number of years. The Detroit Graphite Company was the only operator in 1916.

MINERAL PAINTS.

Certain iron ores were formerly mined in Iron county by the Pickands Mather Company of Cleveland, Ohio, for the manufacture of paint. Last year operations ceased and the only manufacture of mineral paints from the crude material are the Detroit Graphite Company and the Acme White Lead & Color Works, Detroit. The former (See Graphite) utilizes graphitic slate for the manufacture of graphite paint. The latter manufactures a large amount and a great variety of mineral paints. The two above are the only producers, hence figures of production and value cannot be given.

QUARTZ.

Vein quartz is mined near Ishpeming by the Michigan Quartz Silica Company of Milwaukee and ground chiefly for wood filler and paint. Some of the product is used in the manufacture of scouring polishes. According to an analysis submitted by the company the quartz rock is practically pure silica, there being only a trace of impurities. The mills are located at Ishpeming, Michigan, and Milwaukee, Wisconsin.

There is but one producer of quartz hence figures are not given.

FELDSPAR.

Deposits of potash feldspar are reported to occur about one-quarter mile from Republic and in section 22, T. 47 N., R. 29 W., Marquette county. Pegmatitic granite occurs in sections 7 and 18, T. 46 N., R. 41 W., Gogebic county and a pegmatitic dike is exposed near the south quarter corner of section 8.

According to the reports of the Commissioner of Mineral Statistics of Michigan for 1902 and 1903, the Republic deposit is of red potash feldspar. A carload of spar from this deposit was shipped to East Liverpool, Ohio, for use in the manufacture of porcelain. An analysis made of this by an Ohio chemist, is as follows:

	Per cent		Per cent
Silica (SiO_2)	65.25	Magnesia (MgO)	0.23
Alumina Al_2O_3	18.60	Sodium oxide	1.99
Iron Oxide Fe_2O_3	0.40	Potassium oxide	13.40
Lime CaCO	0.38		

According to the chemist there is but little free quartz present in the sample. An attempt was made to develop the property in section 22, T. 47 N., R. 29 W., but apparently without success.

The pegmatite dike in section 8, T. 46 N., R. 41 W. is very coarse, the crystals of orthoclase attaining a maximum of 14 inches in length. The exposure is very small, being a rock knob 20 to 25 paces across and 15 to 20 feet high. More or less exploration would be required to determine the extent of the dike. It is probable that other dikes exist in this and other localities.

CELESTITE.

Celestite or strontium sulphate ($SrSO_4$) occurs in various strata of the Monroe formation in southeastern Michigan. Near Maybee, Monroe county it is found as scattered masses associated with native sulphur in the lower part of the Upper Monroe. At Rockwood, Wayne county, it exists similarly in the Sylvania sandstone. Near Gibralter it occurs as disseminated crystals in the Upper Monroe dolomites. In the glass sand quarry of the American Silica Co., Rockwood, the masses are very numerous in places and some of them are very large. The commercial possibilities of the recovery of the celestite in connection with the quarrying of the glass sand is now being investigated. The masses are imbedded in the friable sandstone and can be readily separated from it.

SUMMARY TABLE OF THE PRODUCTION AND VALUE OF

Mineral Products.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Brick and tile products, number of brick	281,741,000	$2,350,606	282,664,000	$2,451,242
Brick, sand-lime, number of brick	49,292,000	316,732	50,065,000	321,245
Bromine	(a)	(a)	(a)	(a)
Calcium chloride	(a)	(a)	(a)	(a)
Cement, Portland; bbls. made, value cement shipped	3,651,094	3,145,001	4,081,281	4,228,879
Clay, tons	2,043	6,173	1,710	6,504
Coal, tons	1,206,230	2,399,451	1,231,786	2,455,227
Copper, lbs	218,138,408	35,992,837	183,853,409	28,442,806
Glass sand	....	(e)	....	(e)
Graphite	....	(a)	....	....
Grindstones, tons	....	(a)	....	(a)
Gypsum and gypsum products, tons mined	384,297	621,547	423,896	721,325
*Iron ore, long tons	12,649,296	29,003,163	12,677,466	31,947,214
Iron, pig; long tons made; value pig iron shipped	459,975	(b)6,579,048	447,188	(b)6,568,920
Lime, tons made	74,720	311,448	77,088	331,852
Limestone	....	1,139,560	....	1,408,708
Mineral paints	....	(a)	....	(a)
Mineral and spring waters, gallons sold	1,420,465	75,611	884,893	52,642
Natural gas, M. cu. ft	900	1,470	1,805	1,405
Petroleum	....	(a)	....	(a)
Pottery	....	194,892	....	222,883
Precious stones	....	....	....	....
Quartz	....	(a)	....	(a)
†Salt, bbls	10,946,739	2,974,429	11,528,800	3,293,032
Sand and gravel, tons	2,681,821	818,603	6,424,168	1,529,142
Sandstone	....	16,438	....	19,224
Silver, fine oz. Troy	528,453	324,999	295,173	178,284
Trap rock	....	36,206	....	92,201
Miscellaneous	....	522,141	....	540,626
Total	....	$79,931,757	....	$77,860,192

*Figures from Iron Trade Review.
†Exclusive of bromine and calcium chloride.
(a) Included under miscellaneous.
(b) Excluded from total, covered by iron ore.
(c) Estimated.
(d) Copper sales.
(e) Included under sand and gravel.

MINERAL PRODUCTS IN MICHIGAN, 1912-1916.

1914		1915		1916	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
278,384,000	$2,434,872	281,819,000	$2,248,068	288,391,000	$2,705,054
42,465,000	255,784	47,285,000	286,948	72,004,000	499,711
(a)	(a)	600,325	494,271	....	(a)
(a)	(a)	10,558	74,670	....	(a)
4,218,429	4,064,781	4,765,294	4,454,608	4,919,023	6,017,911
1,463	4,572	3,142	5,605	3,454	11,153
1,231,786	2,559,786	1,156,138	(c) 2,139,596	1,076,215	2,695,557
158,009,748	21,426,122	238,956,410	(d)41,775,296	339,599,198	61,831,805
....	(e)	....	(e)	....	(e)
....	....	....	(a)	....	(a)
....	(a)	....	(a)	....	(a)
393,006	705,841	389,791	686,309	457,375	1,066,599
8,835,274	18,965,058	13,151,612	26,574,168	18,626,051	45,884,330
379,619	(b)5,229,948	(b) 486,106	6,624,559	505,646	8,851,361
66,507	287,648	81,359	349,979	86,447	385,341
....	1,457,961	....	1,828,766	....	2,389,763
....	(a)	....	(a)	....	(a)
931,343	70,310	913,765	72,711	996,875	108,867
2,442	1,442	2,060	1,510	1,298	948
....	(a)	....	(a)	....	(a)
....	265,194	....	521,989	....	792,716
....	(a)	....	(a)	....	(a)
....	(a)	....	(a)	....	(a)
11,670,976	3,299,005	12,588,788	4,304,731	14,918,278	4,612,567
3,647,790	1,118,978	3,776,726	1,036,739	4,407,475	1,295,717
....	(a)	....	(a)	....	(a)
413,500	228,665	585,933	297,068	....	247,485
....	34,406	....	105,855	....	83,072
....	565,147	....	119,905	....	971,263
....	$57,641,013	....	$94,003,349	....	$140,446,220

PART III. DEEP WELL BORINGS.

R. A. SMITH.

DEEP BORINGS.

During the past three years a considerable number of deep borings have been sunk in the state chiefly for water, salt, oil and gas. Logs of most of these and sets of samples from many have been obtained. A number of records of wells, drilled prior to 1913, have also been recently obtained. The following are the compiled records of the more important borings.

ALLEGAN COUNTY.

Saugatuck. Mr. P. G. DeGuenther in 1916 drilled a test well for oil near Saugatuck. A log and a set of samples were preserved for the lower portion of the well. The well evidently penetrated the Dundee limestone but no oil or gas was reported. The exact location of the well was not learned.

A detailed record of the lower portion of this well would have been of great value in throwing light on the structure of Dundee limestone in western Allegan county. Since the depth to the top of this formation at Saugatuck cannot be determined within close limits, direct comparison cannot be made with the wells at Allegan to the eastward and in Berrien county to the south.

SAUGATUCK WELL.

Location: Near Saugatuck. Record by R. A. Smith from samples taken at every change and from driller's log. Drilled for oil in 1916 by P. G. DeGuenther.

Elevation not known but probably about 600 ft. A. T.

	Thickness, feet.	Depth, feet.	Sp. taken.
Pleistocene or glacial deposits:			
"Dark loam"	20	20	1
Dark grayish yellow sand with considerable white chert and blue shale. Grayish cast due to shale particles. "Water sand."	20	40	2
Fine yellow sand—"quicksand."	30	70	3
Coarse gravel and boulders with water. 10-in. drive pipe to 85 ft.	10	80	4
Fine sand—"quicksand," and gravel. Quicksand filled up pipe 40 ft.	10	90	5
Fine sand with small pebbles—"quicksand"	10	100	6
Sticky dark bluish boulder clay. "Slow to drill"	15	115	7
"Quicksand"	25	140	8
Gravel and sand, water. "Can't bail down." Sample at 160 ft. is labeled "Clay and gravel"	40	180	9
Clay at 180 ft., pebbly. Record from 180 to 195 ft. not certain	15	195	.....
Quicksand fills up hole 60 ft. Gravel at 285 ft. 8-in. casing to 200 ft.	90	285	10
"Clay, dark and sticky." "(Weathered shale at the top of the Coldwater[?]) "Soapstone" at 305 ft.	20	305	11
Coldwater shale:			
Hard light gray very fine grained grit and gritty dolomitic shale breaking up into hard angular fragments, resembling "Light limestone."	35	340	12
Soft dark gray shale—"Soapstone. Easy to drill"	110	450	13
Hard gray fine grained dolomitic grit, with streaks of white dolomite. No. eff. with cold dilute HCl, vig. with hot. Smooth dark gray shale, very calcareous—"soapstone," at 460 ft.	10	'460	14
Hard gray fine grained dolomitic grit, darker than above. "Blue shale, clean drilling."	50	510	.....
Berea horizon and Antrim shale:			
"Red rock and mixed lime." Gray to light green crystalline limestone with some white calcite and pyrite. Sample labeled 510 ft. is brick red and bright green shale. "Red rock mixed with lime."	25	535	.....
Sample labeled 535 ft. is chiefly very red gritty shale with some yellow shale and much gray to greenish white crystalline limestone and white calcite. Sample labeled 580 ft. is finely mottled gray very dolomitic fine grit	165	700	.....
Soft greenish gray shale. "Soft limestone. Easy drilling."	70	770	.....
Dark gray shale and hard gray, gritty dolomitic streaks. "Soapstone, no grit at 785 feet."	15	785	.....
Greenish gray shale with streaks of limestone; some calcite	15	800	.....
Dark gray bituminous shale, very smooth and soapy.—"soapstone"	80	880	.....
"Limestone and shale mixed." Gray and dark gray shale, calcite	70	950	.....
Clay, blue and sticky at 950 feet	250	1,200	.....
"Limestone and shale mixed." Sample at 1,200 ft. chiefly brown bituminous limestone.			

ARENAC COUNTY.

Pine River. Fred Oeder drilled a well for water near Pine River. The record was made from a few samples and a log from memory furnished by Mr. Oeder. Two gypsum beds were struck at 216 and 223 feet respectively.

PINE RIVER.

Location: Near Pine River, Standish Township. (T. 18 N., R. 4 E.) Drilled in February, 1915 by Fred Oeder, 208 N. DeWitt Street, West Bay City, Mich. Record from memory by Fred Oeder. Not accurate as to details, only for main changes in rock strata. Correlations by R. A. Smith.

	Thickness, feet.	Depth, feet.
Pleistocene or rock surface—Clay	22	22
Parma sandstone—White sandstone	38	60
Bayport limestone—Limestone	60	120
Michigan series:		
Blue shale	96	216
Gypsum (sample about $\frac{1}{3}$ gypsum, rest blue and gray shale)	2	218
Blue shale	5	223
Gypsum—Sample mainly pure crystalline gypsum; some blue and gray shale (Shale probably from above Marshall sandstone—Smith).	8	231
Upper Marshall sandstone—Dark gray sandstone and shale mixed Flowing water.	269	500
Lower Marshall—Red sandy shale	125	625

BRANCH COUNTY.

COLDWATER.

Location: Exact location not given. Record by C. E. Wright from Dr. J. H. Bennett.

Elevation 983 ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial drift—Surface	115	115
Coldwater shale—Blue shale	701	816
Berea horizon (?)—Red calcareous shale	14	830
Antrim shale:		
Hard blue shale interstratified with limestone	50	880
Black bituminous shale	205	1,085
Traverse formation—Hard limestone	115	1,200

CLINTON COUNTY.

Bengal Township. In 1915, coal was struck in a well on the Verne Walker and Albert J. Moss farms on the town line between Bengal and Essex townships. The Consolidated Coal Co. of Saginaw, drilled two test holes one on each farm to determine the thickness and extent of the bed. The coal bed in both borings proved to be too thin for further investigation. Records of the borings were furnished the survey by Mr. J. H. Barnes, Field Engineer of the company and the record of the A. J. Moss hole, the deeper of the two, is given below:

Test Hole No. 1, Albert J. Moss Farm.

Location: Near N. E. cor. S. E. ¼ Sec. 33, Essex Twp. (T. 8 N., R. 3 W.), Clinton Co. about 10 feet from well and 7/10 of a mile N. E. of hole No. 1 on the Vern Walker farm.

Drilled in November, 1915, by Consolidated Coal Co., Saginaw. J. H. Barnes, field engineer. Churn drill. Thickness of coal determined by samples taken about one inch apart by specially devised bit and barrel. Record from J. H. Barnes. See also record of A. J. Moss well, 1915.

Elevation about 765 feet A. T.

	Thickness feet.	Depth feet.
Pleistocene or surface deposits:		
Sand	....	....
Sandy clay	8	8
Clay	42	50
Hard pan	65	115
Clay	10	125
Sandy red clay (or soft red shale?)	17	157
Saginaw formation:		
Shale	3	160
White sandstone	32	192
Gray slate	4	196
Black slate	1	197
Gray slate	10	207
Black slate, very black and oily	17	224
Poor coal	0–9"	224–9"
Sandstone	2–3	227
Fire clay	4	231
Gray sandstone	50	281
Gray sandy slate	57	338
Black slate	1	339
Fire clay	5	344
Black shale	20	364
Gray shale	16	380
Fire clay	2	382
Coal, fairly good	0–7"	382–7"
Fire clay	5–5	388
Gray slate	12	400

The slate above is shale.

DELTA COUNTY.

Escanaba. In 1917 the Chicago and Northwestern Railway Company completed a well for water at their shops in Escanaba. A carefully made log and a complete set of samples were preserved for the Survey by Mr. Geo. Loughnane, Division Engineer.

The well penetrated the red Huronian schists at a depth of about 854 feet. Horizons corresponding to the Madison sandstone and the Mendota limestone of the Wisconsin section occur below the "Calciferous" sandstone. The Lake Superior sandstone contained much coarse very porous sandstone below about 730 feet and yielded a large flow of artesian water, with a head apparently about 30 feet above the surface.

CHICAGO & NORTHWESTERN RAILWAY COMPANY WELL.

Location: C. & N. W. Ry. shops, Escanaba; 250 ft. north and 2,020 ft. west of southeast corner of N. W. ¼ of sec. 29, T. 39 N., R. 22 W.; and 635 ft. east of east line of Georgia Street; and 200 ft. north of north line of Thomas Street. F. M. Gray, Jr., well contractor. D. Curran, driller. Well completed April, 1917. Samples taken under the direction of Geo. Loughnane, Division Engineer. Record compiled by R. A. Smith, Michigan Geological Survey, from samples and from information given by Geo. Loughnane.

Elevation about 590 ft. A. T., 9 ft. above Lake Michigan, or 0 ft. above tracks at yards.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial drift:		
Coarse yellowish sand	10	10
Yellowish red sand	20	30
Coarse yellowish sand or fine gravel	10	40
Gravel, probably water bearing from about lake level down	10	50
Fine pink clay, very calcareous	30	80
Pinkish clay, apparently with gravel at the bottom	5	85
Sandy gravel, "hard pan gravel"	10	95
Very coarse gravel and pebbles	11	106
Galena—Trenton Limestone:		
Hard grayish buff limestone with small white crystalline masses. Violent effervescence with cold dilute HCl. "Shell rock" and pebbles from above	4	110
Hard grayish buff fossiliferous (brachiopods) limestone with orange red streaks and small white crystalline masses. Violent effervescence. Iron oxide decreases downward	20	130
Hard grayish buff limestone with white crystalline masses. Vig. eff. Little or no red iron oxide	10	140
Gray very argillaceous pyritic limestone and calcareous shale. Violent effervescence	20	160
Greenish gray calcareous shale. Moderate to slow effervescence	10	170
Buff gray argillaceous limestone. Vigorous to moderate effervescence	10	180
Gray calcareous shale and light to dark gray very argillaceous limestone	30	210
Gray to dark gray calcareous shale, and shaly and sandy limestone; sand composed of small round grains of colorless quartz	10	220
Gray calcareous shale and grayish white to gray argillaceous limestone. Violent effervescence	20	240
Gray to dark gray calcareous shale and shaly limestone	20	260
Light buff crystalline limestone with some gray to dark gray shaly and black bituminous streaks	50	310
Hard gray gritty limestone. Moderate effervescence	10	320
Light to greenish gray shale and gray limestone	10	330
Much greenish gray shale and dark buff gray limestone	20	350
Light grayish buff limestone with sandy phases; some greenish shale. Moderate to slow effervescence	10	360
Greenish gray to dark gray shale and buff sandy limestone; sand of rounded colorless quartz grains	10	370

	Thickness, feet.	Depth, feet.
Most of the upper beds of limestone are apparently low magnesian; the lower beds appear to be more magnesian, especially near the bottom. The characteristically high magnesian beds of the Galena do not appear to be present in this well but occur on the top of the bluffs near the mouth of the Escanaba River.		
St. Peter (?) Sandstone.		
Light to dark buff and gray magnesian limestone with sandy phases and streaks of dolomitic sandstone. Slow effervescence. Flow of water	10	380
Fine grained light buff sandy dolomite, hard	15	395
Fine white dolomitic sandstone, soft	15	410
Beekmantown—"Lower Magnesian" or "Calciferous."		
Light buff heavy magnesian limestone and much white sandstone, apparently in streaks or in part from the incoherent sandstone above. Slow effervescence.	20	430
White dolomite, hard. Slow effervescence	10	440
White sandy dolomite, hard. Slow effervescence	10	450
Small flow of water from 450 to 480 ft.		
White dolomite and light buff sandy dolomite	10	460
Buff gray dolomite with sandy streaks and streaks of very red ferruginous dolomite	10	470
Fine grained gray dolomite with dark pyritic streaks and dense grained gray dolomite breaking with a smooth conchoidal fracture ("glass rock"?)	10	480
Jordan (?) (Madison) Sandstone.		
White sandstone of rounded colorless quartz grains; apparently some streaks of dolomite	20	500
St. Lawrence (?) (Mendota) Limestone:		
Light buff and gray dolomite with a streak of red dolomite	10	510
Buff and gray dolomite with sandy streaks; residue of 10 to 15% of white quartz sand	10	520
Light buff sandy dolomite; residue of 10-15% of white quartz sand	10	530
Very fine white dolomitic sandstone	10	540
Light buff gray dolomite and dolomitic sandstone, the latter probably in the upper part	10	550
Very red ferruginous dolomite with some white dolomite, probably at bottom. Large residue of red ferruginous matter	10	560
White dolomite	10	570
Light buff and red dolomite; some gray dolomite	20	590
Red buff and gray dolomite redder and apparently harder than above	20	610
Dark gray very argillaceous and pyritic dolomite and gray shale; sandy at the bottom	25	635
Lake Superior or Potsdam Sandstone:		
Gray to reddish sandstone, calcareous at top	55	690
Fine calcareous sandstone	10	700
White sandstone	40	740
Main water bearing horizon said to be from 730 to about 800 feet.		
Coarse white sandstone	20	760
Coarse grayish white to bluish gray sandstone	35	795
Red clay shale, slightly calcareous	5	800
Red and white sandstone, probably red sandstone streaked or mottled with white; fine to medium grained	30	830
Coarse gray sandstone with particles of red rock; probably water bearing; apparently red talcose schist at 850 feet	24	854
Pre-Cambrian:		
Red talcose schist with smooth "soapy" surfaces on cleavage plates; some pieces show crenulations	1–2'	855-2'

Casing: 106 ft. of 8 inch to rock, 5 ft. of 7¼ inch liner, and then 7¼ inch hole to 120 ft., and 6⅛ inch hole to bottom. To prevent caving, 5 3-16 inch casing was put in to 240 ft. to case off the shale rock from about 200 to 240 feet.

Artesian flow estimated at 150 gallons per minute. Water flows freely over top of casing 20 feet above ground. Head probably about 30 feet.

Pine Ridge. A test hole for iron was drilled near Pine Ridge about two and one-half miles west of Escanaba. The hole was abandoned at a depth of 530 feet without reaching the Huronian rocks. Judging from the Chicago and Northwestern Railway well at Escanaba drilled later, the Huronian rocks should occur in the vicinity of Pine Ridge at a depth of nearly 800 feet.

A complete set of samples were preserved and furnished the Survey by Mr. L. N. Schemmel of Escanaba who was connected with the project.

LOUIS N. SCHEMMEL TEST HOLE NO. 1.

Location: S. W. corner S. W. ¼ of N. E. ¼, sec. 28, T. 39 N., R. 23 W. Hole near Pine Ridge or 2½ miles west of Escanaba. Drilled for iron in 1914. Samples practically every 5 feet and at every change. Samples furnished by L. N. Schemmel and examined by R. A. Smith and L. P. Barrett.

Elevation 680 ± ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial drift (30 ft.):		
Sand and "drift"	10	10
Quicksand	8	18
Quicksand and broken limestone	12	30
Bed rock at about 25 ft. First sample at 30 ft.		
"Trenton" limestone (95 ft. Top eroded):		
Galena		
White to light buff and gray dolomitic limestone	19	49
Mixed bluish gray and white dolomitic limestone	5	54
Bluish gray argillaceous limestone and dolomite; pyrite at 125 ft	71	125
Platteville (and Galena in upper part) (?) (188 + 57 ft.)		
Bluish gray to light gray and white limestone	20	145
Dark gray argillaceous, pyritic limestone; some white limestone	15	160
Gray and light buff limestone; some bluish gray shale	5	165
Hard finely crystalline yellowish to grayish white limestone, dolomite, and dolomitic limestone; vein of water at 170 ft. which carried away the drillings; water not artesian	38	203
Dense light grayish dolomite and dolomitic limestone	15	218
St. Peter (?) sandstone:		
White sandy dolomite and dolomitic limestone. Abundant rounded colorless grains of quartz, in places forming more than one quarter of rock. Pyritic in places; vein of water at 248 ft. which carried away drillings; water not artesian	47	265
White sandy limestone. Large amount of small rounded colorless quartz grains	10	275
St. Peter sandstone (50 ft.):		
Pure white sandstone of rounded colorless quartz grains	14	289
Pure white sandstone somewhat calcareous. Drill became "highly magnetic."	5	293
White sandy dolomitic limestone	7	300
Bottom of hole at	.....	304
Drill dropped into a vug and wedged; broke cable about 2 ft. above tools in trying to loosen drill.		

Test Hole No. 2, 30 ft. from Hole No. 1.

No samples down to 300 ft.

	Thickness, feet.	Depth, feet.
White and very calcareous sandstone	10	310
White sandy limestone. Vig. eff	5	315
"Calciferous," Beekmantown (?), "Lower Magnesian" (85 ft.):		
White limestone and much red iron oxide and some argillaceous or clayey matter; limestone eff. vig	4	319
(This red oxidized horizon possibly represents the eroded land surface of the Calciferous upon which the St. Peter was deposited. The St. Peter apparently fills hollows and valleys in the Calciferous formation.)		
Very white limestone and some red iron oxide. Vig. eff. Some white quartz sand	1	320
Very sandy white limestone. Vig. eff	10	330
Grayish white limestone. Vig. eff	5	335
White limestone with some white quartz sand. Vig. eff	5	340
White to very light buff limestone. Mod. eff	5	345
White to very light buff limestone with some white quartz sand. Vig. eff	5	350
White sandstone	15	365
White sandstone and some very white dolomite. Slow eff	15	380
White sandy dolomite. Slow eff	5	385
White dolomite—some sand. Mod. eff	8	393
White dolomite. Mod. eff	3	396
White sandy and pyritic dolomite	4	400
The relatively vigorous effervescence with cold dilute HCl was due to the powdery character of the samples. Coarse particles obtained by washing gave slow reaction.		
Jordan (Madison?) sandstone (25 ft.):		
Very sandy white dolomite	2	402
A little pyrite from 330 to 402 ft.		
White and very calcareous sandstone, nearly half dolomitic limestone, some pyrite; hard, 5% of residue composed of fragments of steel from the drill	1	403
Soft white sandy dolomitic limestone, mod. eff. 20% pure white quartz sand	1	404
Yellowish white sandy dolomite; slow eff. 15% of pure white quartz sand, rather soft; drillings washed away from 404 to 415 ft	11	415
Soft yellowish white sandy dolomite; slow eff. 20% pure white quartz sand	3	418
Soft yellowish white sandy and pyritic dolomite; slow eff. 10% pure white quartz sand	7	425
"Drillings washed away from 420 ft. down." "From 404 ft. down to 425 ft. most of drillings washed away. Water did not rise to top of pipe nor did it overflow."		
St. Lawrence (Mendota?) limestone (84 ft.)		
Medium hard white dolomitic limestone with a little colorless quartz sand and brown ferruginous matter; mod. eff	7	432
Hard white dolomitic limestone with a small amount of brownish gray ferruginous material; mod. eff	3	435
Hard light buff dolomite with much *red brown* iron oxide; very little fine white quartz sand; slow eff	3	438
Hard white dolomitic limestone with a small amount of fine white quartz sand; mod. eff	7	445
Hard white dolomitic limestone with about 5% of fine colorless quartz sand; water turning reddish	5	450
Hard very light buff dolomitic limestone; a little fine white quartz sand and particles of brownish red iron oxide; mod. eff. Water reddish	5	455
Hard reddish buff sandy dolomitic limestone with much *brownish red iron oxide;* brisk eff. About 10% of colorless quartz sand; water colored *red*	5	460
Hard light buff dolomitic limestone with a reddish cast due to considerable *brownish red iron oxide;* brisk eff	2	462
Hard reddish buff sandy dolomitic limestone with considerable brownish red iron oxide and white quartz sand	3	465
Hard red sandy dolomitic limestone with a large amount of *brownish and orange red iron oxide; water blood red*	5	470
Hard light *reddish buff* sandy limestone; vig. eff.; much iron oxide and some fine white quartz sand; water blood red	1	471
Hard *reddish buff* dolomitic limestone, a very little sand and much iron oxide in brownish red particles; limestone fragments largely white; water blood red	1	472
Hard reddish buff dolomitic limestone, much *iron oxide;* limestone fragments varying from white to yellow and red; a little white quartz sand	1	473
ard very red buff dolomitic limestone; larger amount of *iron oxide* than in Hprevious samples; limestone particles white to red and yellow; water blood red	1	474

	Thickness, feet.	Depth; feet.
Hard very red buff dolomitic limestone; still larger amount of *iron oxide;* limestone particles white to yellow and red, with the two latter colors predominating; mod. eff.; water blood red	1	475
Hard deep buff red dolomitic limestone with a very large amount of iron oxide; some white quartz sand	2	477
Very buff red dolomitic limestone softer than at 477 ft. Mod. eff.; large amount of iron oxide; limestone particles chiefly yellow and orange colored; some white quartz sand; water dark blood red	3	480
Soft lighter *buff red* dolomitic limestone; mod. eff.; smaller amount of iron oxide; water dark blood red	2	482
Harder *buff red* dolomitic limestone; slow eff.; water dark blood red	3	485
Very *dark red* dolomitic limestone, softer; mod. eff.; water dark blood red	1	486
Softer very *dark red* dolomitic limestone with a very large amount of iron oxide; slow eff.; limestone particles yellow and orange; some of the iron oxide is in granular particles	4	490
Highly ferruginous and *very sandy* pyritic *red* limestone; vig. eff.; water blood red; residue of about 25% of white pyritic sand	5	495
Highly ferruginous and very sandy pyritic red limestone; vig. eff.; water red and residue of more than 25% of white and very pyritic sand. Color of sludge not as red as at 495 ft	2	497
Reddish gray sandy limestone; brisk eff.; much less *iron oxide*, pyrite, and sand than at 497 ft.; limestone particles white, red, and gray. Water reddish brown	3	500
Sandy gray pyritic limestone; "water blue black;" brisk eff.; limestone particles gray and white with some reddish ones	2	502
Sandy grayish buff limestone; brisk eff.; very little sand but considerable *iron oxide*; limestone particles white and gray	3	505
Very sandy reddish buff pyritic limestone; mod. eff.; residue of 30% white quartz sand; minute pyritic crystals with a considerable amount of iron oxide	4	509
Lake Superior or "Potsdam" sandstone (21 + ft.):		
Reddish buff ferruginous and calcareous sandstone; slow eff.; residue of 60% of white quartz sand; some pyrite	1	510
Light red, very sandy and ferruginous limestone; mod. eff.; residue of about 40% of fine white quartz sand	5	515
Reddish white sandstone; considerable iron oxide; but little calcareous matter	3	518
Reddish white calcareous and ferruginous sandstone; rock is essentially a sandstone	1	519
Calcareous white and red sandstone; sludge reddish gray; water nearly clear; rock hard	3	522
Calcareous white and red sandstone; sludge reddish yellow; rock hard	2	524
Red and white sandstone; sludge reddish yellow	2	526
White and red sandstone; sludge light reddish yellow; less ferruginous than from 524-526	4	530

EATON COUNTY.

Eaton Rapids. A 12-inch well was drilled in 1914 to the depth of 700 feet for the City Water Works of Eaton Rapids by the Frank P. Rust Co. of Detroit. The well apparently penetrated the Lower Marshall and perhaps the Coldwater. The upper sandstones in the Coal Measures and Parma yield a moderate supply of water but those of the Michigan series and the Marshall formation were reported to yield very little water. This is surprising in view of the fact that much of the sandstone in the Michigan series is porous. It appears possible that a proper pumping test was not made.

EATON RAPIDS MUNICIPAL WELL.

Location: At north end of waterworks plant, Eaton Rapids, T. 1 N., R. 3 W., Eaton County. 12-inch hole. Contractor, Frank P. Rust Co., Detroit. Record from notes and samples furnished by W. W. Tuttle, driller in charge. 1914. Samples examined by R. A. Smith.

Elevation 889 ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits—Loose sand	20	20
Coal Measures:		
Sandstone, white; water	15	35
Shale, bluish and black	92	127
Parma Sandstone:		
Sandstone	30	157
Gray sandstone and limestone; former full of small holes and drusy cavities	14	171
Sandstone	30	201
Bayport Limestone:		
White pyritic limestone, cherty, and some gray shale. Violent eff	15	216
Sandstone	40	256
Michigan Series:		
Gray dense dolomite and gypsum	10	266
White sandstone with a greenish cast from numerous green quartz grains	40 ±	381
Pure white sandstone, pyritic	40 ±	421
Shale (This may be the base of the Michigan series)	10	431
Light greenish gray sandstone (Marhsall [?])	43	474
Grayish yellow sandstone with some green quartz grains	42 ±	516
Brown (red) and green shale	29	545
Marshall sandstone:		
Very fine grained light greenish gray sandstone with little lime cement; grades downward into	55	600
Very fine grained light gray and very dolomitic sandstone. No eff. with cold dilute HCl. Sand grains tightly cemented, grades down into	40	640
Lower Marhsall and Coldwater (?) shale:		
Blue gray shale	60	700
Fine grained clay grit—very dolomitic at 700 ft. like that from 600 to 640 ft.		

GRATIOT COUNTY.

Ithaca. In 1917 A. R. Purcell bored a well 785 feet deep at Ithaca. The well is used to increase the municipal water supply.

ITHACA MUNICIPAL WELL.

Location: At Water Works, Ithaca, Gratiot County.

Drilled in 1917 by A. R. Purcell, well contractor, Jackson, Michigan. Record by R. A. Smith from samples furnished by A. R. Purcell. Samples every 5 feet.

Elevation apparently below 747 feet, A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial deposits:		
Clayey sand	5	5
Fine yellow sand, finer and loamy toward the bottom	10	15
Dark pebbly clay	25	40
Pebbly clay, apparantly with sand and gravel at the bottom	5	45
Sand gravel, water bearing	5	50
Sand	5	55
Dark fine grained reddish clay	15	70
Sand and gravel, water bearing	20	90
Sand, water bearing	10	100
Sand and gravel at top and dark fine grained reddish clay	5	105
Dark fine grained reddish clay	15	120
Dark fine grained reddish clay at top and sand and gravel at bottom	5	125
Fine sand	5	130
Pebbly blue clay	5	135
Fine gray sand	20	155
Sand and fine gravel, more sandy toward bottom; water bearing	10	165
Fine sand	5	170
Gravelly sand	5	175
Fine sand	5	180
Sand and coarse gravel and clay apparently at bottom	5	185
Clay at top and sand at bottom	5	190
Dark sand, pebbly	5	195
Fine sand and clay	5	200
Dark red clay with pebbly blue clay probably at about 213 feet	15	215
Blue clay apparently with gravel at the bottom	5	220
Gravel, probably water bearing	5	225
Very calcareous fine grained blue clay. Pebbles in places	40	265
Dark reddish clay with pebbles and sand	45	310
Dark reddish sand with some clay	5	315
Dark reddish clay with pebbles and sand, with pure white gypsum in sample at 325 feet	10	325
Dark reddish clay and pure white gypsum	5	330
Pure white gypsum mixed with some red clay	5	335
Coarse gravel	5	340
Very pebbly red clay and pure white gypsum	5	345
Brick red clay	5	350
Coal Measures:		
Pinkish red and light gray sandstone	10	360
Dark gray to grayish black bituminous shale, black at the bottom; non-calcareous	40	400
Soft light gray shale	5	405
Light gray and dark gray shale, darker toward the bottom	15	420
Dark gray shale to grayish black bituminous shale	35	455
Soft light gray shale	5	460
Soft light gray shale at the top, red sandstone below, and gray sandstone at the bottom	5	465
Yellowish white sandstone	5	470
Fine grayish white sandstone, pyritic in places	105	575

	Thickness, feet.	Depth, feet.
Grayish white sandstone, pyritic in places	20	595
Grayish white very pyritic sandstone; masses of granular pyrite	15	610
Grayish white pebbly sandstone. Small pebbles of white quartz	5	615
Medium fine grained grayish white sandstone	20	635
Gray sandstone and dark gray shale	5	640
Dark gray shale	10	650
Dark gray shale and black bituminous shale with partings of black bituminous matter	15	665
Black very bituminous shale	5	670
Dark gray bituminous shale with some black shale	10	680
Chiefly light gray shale, some dark gray shale, non-calcareous	5	685
Parma Sandstone:		
Gray pyritic sandstone, some shale at top	5	690
Gray pyritic and conglomeratic sandstone. Numerous small pebbles of white quartz; typical Parma sandstone	15	705
Gray sandstone	20	725
Bayport Limestone:		
Light gray to gray limestone; viol. eff. with cold dilute HCl	5	730
Dark fine grained bituminous dolomite; slow eff	5	735
Light gray granular limestone, with very sandy streaks	10	745
Gray sandy dolomite with streaks of dolomitic sandstone	10	750
Gray sandy dolomite at top and light gray shale at the bottom	5	755
Light gray shale at the top and white dolomitic sandstone at the bottom	5	760
White to light gray very dolomitic sandstone	10	770
White to light gray dolomitic sandstone at top and buff to brownish dolomite at bottom	5	775
Chiefly dark brown bituminous dolomite, some buff dolomite	5	780
Gray very pyritic shale	5	785

HOUGHTON COUNTY.

Lake Linden. A deep boring for water was made in 1887 by the Calumet and Hecla Copper Mining Co. at their stamp mill at Lake Linden. A diagrammatic record of the boring was furnished by F. G. Coggin, Superintendent of the mill.

The well penetrated 1,450 feet of "Potsdam" or Jacobsville sandstone without reaching the bottom of the formation.

CALUMET & HECLA COPPER MINING CO. WELL.

Location: At Stamp mill of Calumet & Hecla Copper Mining Co., Lake Linden, Houghton County. Record from diagram and information furnished in 1893 by F. G. Coggin, Supt. of stamp mill. Well begun Jan. 24, 1887, and finished May 12, following.

Elevation about 635 feet. A. T.

	Thickness. feet.	Depth, feet.
Pleistocene or glacial deposits:		
Gravel. Water at 10 feet, then again at 24 feet	26	26
Hardpan	7	33
Quicksand and gravel	17	50
End of 12-inch drive pipe; 10-inch below this.		
"Potsdam" or Jacobsville sandstone:		
Sandstone	6	56
Sandstone, "Pretty solid" in the upper part; loose shale at about 93 feet and solid sandstone below. 82 ft. 2 inches of 10-inch pipe	42	98
Solid reddish sandstone	274	372
Water came in at about 142 feet and rose to within two feet of surface. Previous to this, after casing was in, there was not enough water to drill with. Bottom of pump at about 196 feet. 8-inch hole to 205 feet.		
Solid reddish sandstone but a little harder at top	101	473
Red sandstone. Rock harder from about 580 feet. At 600 feet water rose in well a little	128	601
Very fine sandstone, whiter and harder and with less red clayey matter	5	606
Red sandstone. Very hard at about 1,085 feet, then softer at about 1,130	524	1,130
Red sandstone with some marl from about 1,140 to 1,170 feet. Very hard about 1,267 feet, softer at 1,318 feet and then very hard at 1,330 feet	260	1,390
Coarse white sandstone	112	1,502
Very hard bed of red "marl" at 1,435 feet. Well yielded 60,000 gallons of water per day.		

HURON COUNTY.

Bad Axe. The Sugar Company at Bad Axe drilled a well for water, a number of years ago. The record is given below.

SUGAR COMPANY WELL.

$5\frac{5}{8}$ inch hole.

	Thickness, feet.	Depth, feet.
Surface deposits:		
Muck and shell marls (?) not in original record	5	5
Clay	20	25
Gravel	5	30
Hardpan (glacial material)	5	35
Unreported (discrepancy in the record)	10	40 or 50
Upper Marshall sandstone:		
Sandstone	30	80
White shale (soapstone)	5	85
Sandstone	30	115
Lime rock	8	123
Sand rock	30	153
Lower Marshall sandstone:		
Lime rock	10	163
White shale	27	190
Sand rock	25	215
Apparently the main flow of water was at about 207 feet. This was a strong stream which rose above the surface.		
Lime rock	5	220
White shale	10	230
Sand and lime	20	250
Blue shale	25	275
White shale	20	295
Red sand	5	300
Black lime	7	307
Sand rock	5	312
Black lime	5	317
"Gravel" and sand rock. The gravel is conglomerate	3	320
Coldwater shale:		
Blue shale	15	335
Lime rock	5	340
Probably a nodule of iron carbonate and dolomite ("lime").		
Sandy shale	10	350
Lime rock	10	360
Probably a big nodule of iron carbonate and dolomite ("lime").		
White shale	40	400

INGHAM COUNTY.

Lansing. A twenty-inch well was drilled for water in 1917 by A. R. Purcell of Jackson for the Lansing Water Works. A complete set of samples was preserved for the Survey by Mr. Purcell. The samples show that in the vicinity of the plant most of the sandstone in the Coal Measures above the salt horizon is fine grained and closely cemented to yield water freely. The sandstones in the Coal Measures generally vary greatly in texture and prosity, sometimes within very short distances. It is probable that, if exploration was carefully made and complete sets of samples preserved, more porous and more freely water bearing areas of sandstone could be discovered, in or about the city.

LANSING MUNICIPAL "20 INCH" WELL.

Location: Directly north of office of Cedar Street pumping station, about 200 feet south of Michigan Avenue and 200 feet west of Cedar Street. Drilled in 1917 by A. R. Purcell, well contractor, Jackson, Michigan. Record from samples taken by A. R. Purcell.

Elevation of well curb 833.3. ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial drift:		
Yellow pebbly clay	12	12
Clay and gravel or very pebbly clay	8	20
Sandy gravel	10	30
Gravelly sand	15	45
Coal Measures:		
Fine white sandstone, very calcareous	5	50
Fine white sandstone, micaceous	10	60
Very fine white sandstone, very micaceous	10	70
Fine gray grit, argillaceous, micaceous, and calcareous	5	75
Fine gray sandstone	5	80
Fine gray sandstone, micaceous	5	85
Fine gray grit, argillaceous, micaceous, and calcareous	10	90
Fine light gray, sandstone, micaceous	5	95
Fine gray grit, argillaceous and calcareous	5	100
Fine gray sandstone	5	105
Fine gray grit, argillaceous, micaceous, and calcareous	10	115
Fine light gray grit, argillaceous and calcareous	5	120
Light gray very gritty shale, calcareous	5	125
Fine white to grayish white sandstone	90	215
Very fine white sandstone	10	225
Gray sandstone	10	235
Fine gray sandstone	5	240
Fine gray argillaceous sandstone	5	245
Fine white sandstone	5	250
Fine gray argillaceous sandstone	5	255
Very fine white sandstone	40	295
Dark gray sandy shale	20	315
Very fine grayish sandstone, more or less argillaceous and shaly	10	325
Grayish white sandstone, medium to fine grained	35	360
Fine grained sandstone, argillaceous and shaly	5	365
Very dark gray shale	5	370
Light to medium gray shale, non-calcareous	7	377
Most of the sandstone in this well is too fine and close grained to yield water freely.		

IONIA COUNTY.

Ionia. In 1910, E. E. Strope of Mason drilled nine water wells for the city of Ionia. The striking fact concerning these wells is that most of them penetrated a gypsum bed at the top of the Coal Measures. The bed varied in thickness from 4 to 10 feet. Similar occurrences of gypsum are reported by coal drillers in Saginaw county. A log and samples of the gypsum were furnished the Survey by Mr. Strope.

IONIA MUNICIPAL WELL NO. 1.

Location: On the flats of Grand River south of the city. One of 9 wells. Drilled in 1910 by E. E. Strope, Mason, Mich.

Elevation 660 ± ft. A. T.

	Thickness, feet.	Depth, feet.
Surface deposits:		
Sand and gravel	14	14
White hard-pan, soft	28	42
Blue hard-pan, stone all the way through (Boulder clay)	22	64
Red clay	29	93
Coal Measures:		
Gypsum	4	97
Red sandstone	4	101
Shale	62	163
Sandy shale	12	175
Blue shale	48	223
Sandy rock (sandy shale or grit)	44	267
Blue shale	6	273
Blue sandstone	25	298
White sandstone	12	310
Brown shale	5	315
Blue sandstone	16	331
Bayport limestone (?):		
Limestone	5	336

JACKSON COUNTY.

Jackson. In 1916, the Eastern Michigan Power Co. drilled a well for water near their plant in Jackson. A careful set of samples were preserved and furnished to the Survey by Mr. A. R. Purcell, the well contractor. The samples indicate that the Saginaw Coal Measures extend to the depth of about 55 feet and from this depth, the Parma and Marshall sandstones, generally very fine and locally very argillaceous, extend to the depth of over 400 feet. Apparently the chief water bearing horizons are in the upper and lower portions of the sandstone. The sandstone, though fine grained, locally is poorly cemented and yields water rather freely.

EASTERN MICHIGAN POWER CO. WELL.

Location: At Plant of Eastern Michigan Power Co., corner of Mechanic and Trail Streets, Jackson. A. R. Purcell, Well Contractor. Rob't Porlier and C. J. Imler, drillers. Well drilled in 1916. Record by R. A. Smith from samples and data furnished by A. R. Purcell.

Elevation 940 + feet. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Surface material	2	2
Coal Measures:		
Fine grained argillaceous sandstone chiefly	33	35
Soft gray clay shale or "fire clay." Depth of bottom of this uncertain	20 ±	55 ±
Soft dark gray micaceous and bituminous shale, non-calcareous. Black specks of bituminous matter	2 ±	57
Parma and Marshall Sandstones:		
Fine grained thin bedded micaceous gray sandstone with numerous black particles, apparently bituminous matter	7	64
Gray sandstone, water bearing	42	106
Gray sandstone with very small scattered pebbles or grains of white quartz	7	113
Soft gray sandstone	7	120
Gray calcareous sandstone and streaks of black shale	7	127
Gray sandstone with scattered coarser grains; some soft fine grained argillaceous sandstone probably at bottom	7	134
Soft fine grained argillaceous sandstone	35	169
Bluish gray calcareous sandstone, coarser and less argillaceous than above but becomes finer grained again toward the bottom	14	183
Gray sandstone	21	204
Fine grained sandstone	7	211
Very fine grained gray shaly sandstone	7	218
Bluish gray gritty shale and very fine grained shaly grit toward the bottom	14	232
Bluish gray gritty shale	7	239
Bluish gray shaly fine grained sandstone and fine grained gray sandstone	7	246
Fine grained shaly sandstone and gritty blue shale	7	253
Very gritty blue shale	28	281
Very shaly fine grained sandstone and very gritty shale	28	309
Very fine grained sandstone, much less argillaceous	7	316
Very gritty bluish shale	7	323
Dark gray very calcareous and argillaceous fine grained sandstone	14	337
Gray very shaly grit or fine grained sandstone	7	344
Gray gritty shale and shaly grit or very fine grained shaly sandstone	35	379
Fine grained gray calcareous and argillaceous sandstone	14	393
Fine grained gray sandstone	7	400

KENT COUNTY.

Rockford. The village of Rockford drilled an 8-inch well for water in 1914. A moderate flow of very hard water being found between 180 and 190 feet. From descriptions of the well churnings, it is probable that gypsum was encountered in this well, indicating the extension of the Grand Rapids-Grandville gypsum area northeast of Grand Rapids for a distance of 10 miles or more.

ROCKFORD MUNICIPAL WELL.

Location: Rockford, Kent County. A. H. Smith Company, Toledo, Ohio, contractors. R. H. Kersey, driller. Well completed in 1914. Record furnished by A. H. Smith of 8-inch test well. Provisional correlations by R. A. Smith.

Elevation 782 ± feet. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial deposits:		
Sand	35	35
Blue clay	45	80
Muddy sand	5	85
Red clay	40	125
Chalky substance (gypsum[?])	2	127
Coal Measures or Michigan series:		
Shale rock	53	180
Water bearing rock. Flow 21 gallons per minute at 185 ft.; temperature 52½° F.	10	190
Rock crystals	1	191
Shale and clay. Water not increased below 185 ft.	19	210
Two of the wells shot which increased their flow.		

LENAWEE COUNTY.

Blissfield. The Continental Sugar Co. of Blissfield drilled a test well for water in 1914. The rock waters were found to be more or less strongly sulphated. A suitable water supply was afterward found in sand and gravel beds near the base of the overlying drift.

TEST WELL OF CONTINENTAL SUGAR CO.

Location: Near plant of Continental Sugar Co., Blissfield, T. 7 S., R. 5 E., Lenawee County. Drilled in 1914 by Wm. C. Mohr. Record by R. A. Smith from driller's log and notes furnished by A. H. Smith of A. H. Smith Company, Toledo, Ohio.

Elevation 690 ± ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Sand (estimated)	10	10
Blue clay (estimated)	40 ±	50 ±
Hard pan (possibly Illinoian till)	30 ±	80
Sand and water bearing gravel (estimated at 2 to 3 ft.)	2½	82½
Unrecorded, probably hard clay or "hard pan"	22½	105
Antrim shale:		
Soapstone	100	205
Black shale with a vein of gas at 240 ft	100 ±	305 ±
Traverse (Hamilton and Marcellus formation):		
Soapstone and mixed rock (probably calcareous shale and thin hard beds of limestone and shales). Strong flow of black water saturated with sulphur and salt. Water very rank from hydrogen sulphide and iron	45	350
Vein of clear water saturated with 30 percent of salt at	......	380
Hard sand like rock—would cut glass, 3 to 4 ft. thick at	......	405
Limestone (probably Dundee limestone in part)	142	547
5½ inch casing to 440 ft. 4½ inch casing below.		

LIVINGSTON COUNTY.

Howell. A water well was drilled for the Howell Water Works by A. R. Purcell of Jackson who furnished the Survey a complete set of samples. This well shows that locally the Coal Measures down to 329 feet are largely very fine grained sandstone and shale and yield scant supplies of water. The most promising source of supply appears to be in the sand and gravel just above bed rock.

HOWELL MUNICIPAL WELL NO. 4.

Location: At Water plant, Howell, Mich. Drilled in spring of 1917 by A. R. Purcell, Well Contractor, Jackson, Mich. Record by R. A. Smith from samples taken every five feet by A. R. Purcell.

Elevation about 915 feet. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Blue clay	5	5
Gravel, very coarse at top	10	15
Fine gravel	20	35
Coarse gravel, waterbearing	10	45
Sand, gravelly at top grading to fine sand at bottom, water bearing	15	60
Fine loamy sand	15	75
Dark clay	5	80
Fine sand, coarser at bottom	10	90
Coarse sand, water bearing	10	100
Coal Measures:		
Fine gray sandstone	10	110
Soft blue non-calcareous shale	5	115
Fine grained sandstone apparently with shaly streak at 135 feet	25	140
Very fine close grained gray sandstone clayey and calcareous	10	150
Blue shale, apparently soft, slightly calcareous	25	175
Very fine and close grained calcareous gray sandstone or grit	10	185
Very fine and close grained calcareous gray sandstone with a streak of blue shale	5	190
Very fine and close grained gray calcareous sandstone with clayey partings	25	215
Soft blue shale	15	230
Very fine gray calcareous grit with clayey partings	15	245
Soft blue shale	5	250
Soft light blue and gray shale and calcareous gray grit	5	255
Black and brown shale	15	275
Dark gray calcareous shale	15	290
Black and brown shale	39	329

Cohoctah Township. A well was drilled for water by Frank Chapman of Fowlerville on the F. & C. Burkhart farm about 10 miles northwest of Howell in Cohoctah township. A detailed log and a set of samples were preserved for the Survey by Mr. Chapman. Very little water was found at any horizon and brine was below 400 feet. The fine-grained closely cemented sandstone and gritty shales provisionally referred to the Marshall are very similar to the section below 55 feet in the Eastern Michigan Power Co. well at Jackson, a record of which appears on another page of this report.

F. & C. BURKART WELL.

Location: Just south of W. ¼ corner sec. 33, T. 4 N., R. 4 E., Livingston Co. Farm of Frank and Claude Burkart. Drilled in 1915 by Frank Chapman, Fowlerville, Mich. Record by R. A. Smith from samples and data furnished by Frank Chapman.

Elevation about 915 ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Light sand	20	20
Fine water sand	12	32
Hard pan	3	35
Blue boulder clay—Boulder shot at 47 ft	12	47
Yellow and blue clay—Boulder shot at 88 ft	41	88
Water sand and blue clay	27	115
Coal Measures:		
Shale and sand rock	3	118
Apparently a little lime rock at 116 ft.		
Soapstone	2	120
Last shot to get casing through sandstone.		
Unreported	5	125
Drove 3½ inch casing to 125 ft.		
Blue shale and sandstone alternating, the shale soft and "dissolved," i. e. slacked quickly in water. At 150-170 ft. largest supply of water; poor and muddy. At 253 ft. sulphate water	135	260
Shale and sandstone mixed with white clay	35	295
Parma sandstone:		
Fair sandrock	20	315
Blue shale	8	323
Light sandy grit	22	345
Michigan Series (?) (Bayport limestone absent?):		
Light colored soft rock like gypsum	7	352
Sand and grit	3-6"	355-6"
Cased with 2 inch casing inside the 3½ inch to 355 ft. 6 in.		
Fine grained gray micaceous sandstone	4-6"	360
Soft blue and white clay shale	3-2"	363-2"
Ceased drilling until Sept. 22, 1915. Samples from 360 ft. to bottom of well.		
Soft shale	1-10"	365
Light gray fine grained sandy or gritty shale	3	368
Soft blue shale, calcareous	2	370
Fine grained calcareous sandstone, easy drilling	2	372
Hard fine grained brownish gray bituminous sandstone, hard to drill	1	373
Smooth unctuous brown bituminous shale	13	386
Hard brown and black shale	0-6"	386-6"
Blue, green and gray limestone	0-6"	387
Very fine grained calcareous, argillaceous and pyritic sandstone	1	388
Fine grained ferruginous and shaly sandstone	2	390
Very fine grained white sandstone	5	395
2 inches blue shale or clay at 394 ft. 6 in.		
Gray sandstone and light blue shale	1	396

	Thickness, feet.	Depth, feet.
Marshall sandstone (?):		
Fine grained calcareous sandstone, hard drilling	4	400
Water fresh or only slightly brackish at 396 ft., salt increasing with depth, brine at 400 ft.		
Very fine grained calcareous sandstone (mod. eff.) and some sandy gray shale. "Easy cutting"	2	402
Fine grained white and gray sandstone, very calcareous, (Vig. eff.) "Very hard, cuts like flint"	3	405
Light buff fine grained sandstone with a thin layer of chert at the top. "Cuts easier"	2	407
Buff fine grained sandstone. "Elastic, cuts like gypsum"	5	412
Very fine grained buff gray sandstone. "Chips come up, cuts harder"	4	416
"No chips, softer; easy cutting. Drill rods covered with a white scale"	4	420
White very fine grained calcareous sandstone	5	425
Gray very fine grained sandstone or grit. "About 8 inches of hard stone at 434 ft. 1 in. A little salt water"	9-9'	434-9'
Blue gritty shale. "Cuts hard."	3	437-9'
Fine grained gray sandstone or grit. Cuts hard	4-3'	442
Dark blue shale and streaks of fine grained grit. Cuts very hard. Used 3 drills and reamer could get nothing from 444 ft. 3 in. to 445 ft. 9 in. Brine	3	445
"White shale between streaks of hard fine grained grit"	2	447
Hard fine grained sandstone, calcareous	2	449
Alternating layers of dark gray shale and fine grained sandstone, harder toward the bottom; one foot of dark bituminous shale	6	455
Very fine grained sandstone or grit and calcareous gray shale	4	459
Soft dark gray bituminous and calcareous shale	1	460
Soft very dark gray shale and streaks of fine grained grit about every five feet	15	475
Soft fine grained sandstone with hard streaks about 6 inches thick	10	485
Very hard fine grained sandstone or grit. No shale	1-8'	486-8'
Shale and fine sandstone to (No samples)	......	506

MACOMB COUNTY.

Mt. Clemens. A number of deep wells have been drilled by the various bathing establishments at Mt. Clemens. A record of one of the older wells, the Carson, was published in Publication 14. The records of the Olympia and Clementine bath house wells were furnished the survey by Dr. G. A. Persson of Mt. Clemens. The Clementine well is 1,500 feet in depth but the record is very unsatisfactory. The Olympia well is shallower but the record, given below, is more satisfactory.

The rock waters are more highly mineralized with depth, therefore most of the wells are drilled to the depths necessary to obtain water having a specific gravity or "strength" sufficient to exert a decided buoying up effect on the bather. Some of the wells yield considerable gas which is used in firing the boilers used for pumping and heating purposes.

THE OLYMPIA WELL.

Location: At Olympia Bath House, Mt. Clemens, Macomb County. Record from Dr. G. A. Persson, Mt. Clemens. Correlations by R. A. Smith.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial deposits:		
Clay	40	40
Sand	98	138
Antrim shale:		
Black slate or shale	116	254
Traverse formation:		
White lime	46	300
Soapstone or calcareous shale	100	400
Lime	10	410
Shale	20	430
Dundee (Onondaga) limestone and Upper Monroe or Detroit River series:		
Red lime. Water at 620 feet	470	900
Sandy lime. (Upper part of Sylvania ?)	75	975
Sylvania sandstone—White sand	55	1,030
Lower Monroe or Bass Island series—Gray lime	235	1,265

Mt. Clemens. In 1913, F. E. Spence of Detroit drilled a well 3,182 feet in depth for oil on the Denewelt Brothers farm about two and one-half miles north of Mt. Clemens. At this depth, the cable broke. The well penetrated the red Queenston shales at the top of the Richmondian but was abandoned. No noteworthy signs of oil or gas were reported.

A good driller's log was furnished the Survey in 1915 by Mr. Spence. According to the log the aggregate thickness of the salt beds is 576 feet, comparable to the thicknesses of the salt beds penetrated at Royal Oak, Oakland county, and at Dearborn, Wayne county. Near the bottom of the salt bearing horizon, one bed is 316 feet thick and probably is to be correlated with the thick bed penetrated in the deeper wells to the southwest along Detroit River. Very probably this bed contains partings of dolomite and shale.

DENEWELT BROS. WELL.

Location: Two and one-half miles north of Mt. Clemens on Denewelt Bros. farm. T. 3 N., R. 13 E. Drilled in 1913 by F. E. Spence, 44 Mt. Vernon Ave., Detroit, Michigan. Record by R. A. Smith from driller's log furnished by F. E. Spence.

Elevation about 610 (?) feet.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Chiefly clay with thin beds of sand and gravel; 10 inch drive pipe to 213 ft; 8 inch to 244 ft	244	244
Antrim shale:		
Limestone (probably in part dolomite and iron carbonate concretions)	10	254
Black shale	46	300
Traverse formation (Hamilton):		
Limestone and shale	50	350
Hard sandy limestone	25	375
Limestone and shale	25	400
White shale (Bell or Marcellus)	175	575
Dundee (Onondaga) limestone:		
Hard limestone	25	600
Limestone	75	675
Salt water to 660 ft. Line of separation between Dundee and Upper Monroe not recognized but should occur between 675 and 700 ft.		
Upper Monroe or Detroit River Series—Limestone (dolomite)	305	980
Sylvania or Middle Monroe:		
Fine sand (white sandstone resembling granulated sugar[?])	150	1,130
Lower Monroe or Bass Island Series—Fine grained limestone (dolomite)	370	1,500
Salina formation:		
Rock salt	40	1,540
Limestone (dolomite)	15	1,555
Rock salt	75	1,630
Limestone (dolomite)	42	1,672
Rock salt	62	1,734
Limestone (dolomite)	103	1,837
Rock salt	33	1,870
White shale	10	1,880

	Thickness, feet.	Depth, feet.
Limestone (dolomite)	64	1,944
Rock salt	316	2,250
Hard limestone (dolomite)	175	2,425
Shale	5	2,430
Limestone (dolomite)	20	2,450
Rock salt	50	2,500
Guelph (Upper Niagaran) and Lockport formations. Limestone (dolomite chiefly)	280	2,780
Upper part bluish to sugary white very crystalline dolomites of H. R. Ford well, Dearborn from 2,225 to 2,320 ft. Ford Motor Co. well, Highland Park, from 2,395 to 2,485 ft. Leamington Oil Co. Well, Leamington, Ont. from 1,075 to 1,495 ft. Lockport relatively thin and probably gray argillaceous dolomites.		
Cataract formation:		
Shale	38	2,818
Red rock (red shale or clay)	20	2,838
White shale	72	2,910
Limestone (Manitoulin)	64	2,974
Queenston Shale	16	2,990
Red rock (red shale and clay)	132	3,122
Limestone	60	3,182
Lost tools in hole and abandoned well. Top of Trenton is probably 350 ft. or more below bottom of hole.		

MANISTEE COUNTY.

Manistee. In 1913 the Louis Sands Salt and Lumber Co. of Manistee drilled a new salt well at their plant. A very complete log and set of samples were preserved for the Survey by Mr. C. W. Smith, President of the company. Particular attention was directed toward the possible occurrence of commercially important quantities of oil and gas but only a strong smell of petroleum was struck at about 1,305 feet, and other depths below. A rock salt bed over 27 feet thick was struck at 1,987 feet.

LOUIS SANDS SALT AND LUMBER COMPANY WELL NO. 4.

Location: South end of Cross St. and 132 ft. 4 in. south of south line of Lake St., Manistee; also 105 ft. south of No. 3 well and 276 ft. west; and 113 ft. 4 in. south of No. 2 well, and 56 ft. 9 in. west of same. Drilled by Peter McGahan. Well was begun Aug. 7, 1913. Record by R. A. Smith from a very complete set of samples and from a carefully made log by T. B. Jones, Supt. Samples and log furnished by C. W. Smith, President.

Elevation of well 17 ft. 10 in. above Lake Manistee, or 598 ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial deposits:		
Yellow sand	7-10"	7-10"
Coarse sand and fine gravel	20	27-10"
Fine light yellow sand	18-8"	46-6"
Coarse sand with very coarse gravel and stone at 95 ft	48-6"	95
Very calcareous reddish brown clay; Viol. eff. with cold dilute HCl	3	98
Sand and fine gravel	22	120
Very calcareous reddish brown clay; viol. eff	4	124
Fine yellowish white sand; water temp. 63° F	16	140
Fine yellowish white sand	13	153
Partly carbonized wood—stems and branches of plants and a cone from some cone bearing plant; cone similar to a small pine cone. Pre-Wisconsin peat bed	......	153
Fine yellowish white sand	28	181
Brownish red clay, very calcareous; viol. eff	4	185
Coarse yellowish gray sand and fine gravel	2	187
Light blue very calcareous clay; viol. eff. (just enough for sample). Black carbonaceous loam; mod. eff.; much carbonaceous material, bits of carbonized plant stems, etc., "Just enough for sample." at	......	187
Fine calcareous sand and gravel. Pebbles of limestone and chert form a conspicuous proportion of all the gravels down to this point	23	210
Yellowish gray sand and gravel	2	212
Fine white "quicksand"—fine calcareous sand with 10 to 15 percent of marl and clay; viol. eff	2	214
Sand and gravel, "water sand" of driller, water temp. 62° F. "Quicksand inside of 10" "drive pipe for 150 ft."	2	216
Sand and gravel with water (sample mainly gravel)	22	238-7"
Extremely calcareous light gray clay; vig. eff. Clay apparently 20% to 25% marl	5	243-7"
Yellowish white sand—"quicksand"	24	267-7
Gray clay; sample chiefly sand, probably in great part from the quicksand above. Water at 269 ft.—Temp. 53° F	1-5"	269
Highly calcareous light gray clay and "hardpan;" vig. eff	4	273
Very calcareous red clay; viol. eff	25	298
Yellowish gray sand—"quicksand" "hardpan"	115	413
Red highly calcareous clay—"hardpan"	1	414
Fine yellowish gray sand with water; Temp. 53° F	2	416
Red and very calcareous clay, "hardpan"	22	438
Very fine yellowish gray sand	17	455
Red and light gray calcareous clay and "hardpan"	26	481
Red calcareous clay and fine yellowish gray sand	14	495
Red calcareous boulder clay	35	530
Coarse gravel and red clay "some gas"—the first struck. "Strong indications of gas" down to 118 ft. Pressure gage reg. 5 lbs. after well had stood 12 hrs.; gas cased off with 8 in. drive pipe.	23	553

	Thickness, feet.	Depth, feet.
Dark blue sticky clay, some gas—non-calcareous; little eff	43	596
Light blue non-calcareous clay; little eff	16	612
Coldwater (Cuyahoga) shale:		
Light blue shale; slightly eff	6	618
8 ft. drive pipe drove to 627 ft. 8½ in.		
Blue shale—some light blue; non-calcareous	92	710
Antrim (Genesee) shale:		
Dark gray and black shale, some very bituminous streaks	30	740
"Brown shale" and "strong smell of crude oil" at 710 ft. The brown color is probably the red top of the Antrim.		
Black and brown very bituminous shale, pyrites	87	827
"Dark brown shale and strong smell of crude oil."		
Very bituminous dark brown shale	13	840
Dark brown bituminous shale	23	863
Black and very dark gray bituminous shale with streaks of blue	11	874
Dark brown and very bituminous shale; powder burns readily before the blowpipe	5	879
Dark to light brown bituminous shale	23	902
Dark brown bituminous shale	10	912
Traverse (Hamilton) formation:		
Gray to dark gray and black bituminous pyritic shale, some limestone. Vig. eff	21	933
Gray limestone, dark gray and brown calcareous shale limestone; Vig. eff	12	945
Chiefly gray dense grained limestone, some very calcareous shale and shaly limestone. Limestone vig. eff. with large residue of clay	7	952
Dense grained gray limestone, vig. eff	12	964
Very calcareous blue shale and argillaceous limestone, pyritic and fossiliferous; vig. eff	10	974
Hard gray limestone; vig. eff. Black water at 983 ft	9	983
Buff gray limestone chiefly with some white; vig. eff. "Water filled hole to top of pipe"	20	1,003
Buff to gray bituminous limestone, some white; "salt and pepper" limestone; vig. eff. Considerable amount of bituminous oily matter	25	1,023
Buff gray and white limestone, more white limestone and less oily matter than in sample preceding. "Salt & pepper" limestone. Pure white chalk or marl at 1,028, reported by driller as "gypsum and only enough for a sample" but the material violently eff. and completely dissolves in cold dilute HCl	5	1,028
Blue, non-calcareous shale with pure white chalk or marl similar to above. Probably from the seam at 1,028	7	1,035
Brown to buff hard sandy and bituminous limestone; vig. eff.; residue 20% pure white quartz sand with round uniform grains. Much oily bituminous matter	.....	1,041
Sandy white finely crystalline limestone; vig. eff. 10% white quartz sand residue. "Only enough for a sample." Weak mineralized brine at	.....	1,041
Buff and gray bituminous limestone, some white "salt and pepper" limestone; vig. eff	20	1,061
Gray very calcareous shale; vig. eff. 80% clay residue	31	1,092
Crevice or geode	3	1,095
White chalk or marl, vig. eff.; practically all dissolves. "Only enough for sample" at	.....	1,095
Light gray to light buff limestone, and chalk or marl; vig. eff	20	1,115
Dark brown and black bituminous shale and limestone, gray and buff fossiliferous limestone; vig. eff. Large amount of bituminous and oily matter. Shells of Atrypa reticularis	10	1,125
Gray and buff gray limestone, vig. eff	20	1,145
White gray very pyritic limestone and much gray chert; vig. eff. Pyrite chiefly in white limestone in minute crystals	32	1,177
Soft gray calcareous shale; vig. eff	24	1,201
Gray limestone with some shale; vig. eff	15	1,229
Gray shale, limestone and chert; vig. eff. A little gypsum, crystals of selenite	23	1,252
Dark brown bituminous limestone with white limestone; vig. eff	10	1,262
Buff gray and white limestone; viol. eff	11	1,273
Grayish buff limestone; vig. eff.; some gypsum, massive crystalline variety	9	1,282
Light grayish buff limestone; vig. eff	5	1,287
Hard light yellow and dark grayish buff limestone; vig. eff	6	1,293
Chiefly dark grayish buff limestone, bituminous and argillaceous. Residue 10 to 15% of clay. Much oily and bituminous matter. Vig. eff	12	1,305
Brown and black bituminous limestone and white limestone. The white is apparently from heads of stromatopora imbedded in the matrix of brown and black bituminous limestone similar to the Rockport beds at the base of the Traverse. "Soft easy drilling. Strong smell of petroleum"	3	1,308

	Thickness, feet.	Depth, feet.
Light brown bituminous and white stromatoporoid; limestone vig. eff.	28	1,336
Light brown bituminous and white stromatoporoid limestone; vig. eff.	16	1,352
Chiefly very bituminous black and brown limestone, a little white stromatoporoid limestone; vig. eff. Strong smell petroleum, large amount of bituminous matter	23	1,375
Brown and black very bituminous limestone, some white stromatopora rock. Strong smell of petroleum and a large amount of bituminous matter	7	1,382
Light buff, brown, very bituminous black limestone; some white coralline and stromatoporoid rock; vig. eff.; considerable amount of bituminous matter	18	1,400
Hard grayish buff, brown, and black bituminous limestone, some white; vig. eff	15	1,415
Hard, grayish, buff, brown and black bituminous limestone, a little white calcite and white limestone, vig. eff	26	1,441
Grayish buff, brown, black, bituminous limestone, considerable calcite and grayish white crystalline limestone; vig. eff.; considerable bituminous matter. "Soft rock, easy drilling" from 1,441 to 1,469 feet	28	1,469
Dark grayish brown and some black limestone; vig. eff.; very little white limestone, very bituminous	25	1,494
Bell (Marcellus) shale:		
Soft calcareous shale; mod. eff. Caves. According to log this is given as "Dark-gray lime rock" but the sample is labelled "gray shale, caving rock"	33	1,527
Gray slightly calcareous shale; mod. eff. Caves; apparently somewhat harder than above	11	1,538
Dundee (Onondaga) limestone:		
Soft, very pyritic white to buff gray limestone; large residue of insoluble material chiefly pyrite and argillaceous matter most of which was apparently from the shale above. Very viol. eff	18	1,556
Soft pyritic buff gray limestone; some white; vig. eff. "Soft easy drilling" from 1,527 to 1,580 feet	24	1,580
Hard gray pyritic limestone; some white; viol. eff	19	1,599
Hard dark gray pyritic limestone, some white and some black bituminous limestone. A little white quartz sand; mod. eff	8	1,607
Hard dark buff gray very bituminous pyritic limestone, some small white rounded quartz grains; viol. eff. Put in 5 to 6 inch liner pipe to depth of 1,620 ft	27	1,634
Hard brown very bituminous limestone; very viol. eff	8	1,642
Very hard brown and very bituminous and pyritic limestone, viol. eff. A little white quartz sand. Much black bituminous residue	12	1,654
Very hard light grayish buff limestone, very little pyrite and bituminous matter. "Very hard drilling" from 1599 to 1675 feet	21	1,675
Soft buff limestone, viol. eff. "strong smell of crude oil"	5	1,680
Very hard grayish buff limestone, viol. eff	36	1,716
Monroe formation:		
Light brown magnesian limestone, very bituminous and apparently very hard. Mod. to brisk eff.; effervescence much slower than in any of the preceding samples of limestone	15	1,731
Gray and brown bituminous limestone, viol. eff	5	1,736
Chiefly dark grayish brown bituminous dolomite, very bituminous. Some very black particles of limestone and considerable pure white limestone and calcite, probably from geodes and fossiliferous rock	27	1,763
Light brown dolomite; brine and strong smell of petroleum at 1,766 feet; 30 per cent brine at 1,780 feet	16	1,780
Light brown dolomite	69	1,849
Hard light brown dolomite, with soft strata at about 1,942 (?) ft. Brine 81 per cent, salinometer test	137	1,987
Salina formation:		
Rock salt	27-6"	2014-6"

MARINETTE, WISCONSIN.

Marinette. Two wells were drilled by the city of Marinette, Wisconsin, which is across the river from the city of Menominee, Michigan. The first hole was drilled only 716 feet and the tools lost at that depth, but the second hole, only eight feet from the first was drilled 978 feet deep, penetrating the pre-Cambrian rocks for nearly 200 feet. A brief record of the first well was published in the Annual Report of the Geological Survey for 1903 and a summary record of the second well in the Annual Report for 1904. A good set of samples were preserved from the second well. A study of the samples and especially a comparison with the very complete sets of samples from the recent borings at Escanaba and Pine Ridge, Delta county (see Delta county) throw much light on the geology along the west side of Green Bay. For this reason it has been deemed advisable to publish the record of the deeper Marinnette well in detail.

MARINETTE MUNICIPAL WELL NO. 2.

Location: At city water works, Marinette, Wis. Samples preserved by H. B. Simcox. Record by R. A. Smith from samples, and data published in the Annual Reports of The Geological Survey for 1903 and 1904.

Elevation about 600 (?) feet A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or glacial deposits—Sand and gravel	69	69
Galena-Trenton:		
Very bright buff dolomite, mod. to slow eff	31	100
Bluish gray, crystalline dolomite, some light colored, sandy dolomite; rounded quartz grains embedded in the dolomite; mod. eff	25	125
Sandy "salt and pepper" dolomite—a mixture of white and bluish gray, crystalline dolomite. Considerable amount of rounded, colorless quartz sand	20	145
Sandy gray to white crystalline dolomite, slow eff. considerable colorless quartz sand	15	160
Gray to dark gray crystalline dolomite, slow eff. a little white sand	15	175
Gray crystalline dolomite, slow eff.; a little white sand	15	190
White and light buff crystalline dolomite, slow eff. some blue shale and colorless quartz sand	25	215
Gray to light buff crystalline dolomite, slow eff.; a fragment of dark brown dolomite; some colorless rounded quartz grains embedded in the dolomite	10	225
Grayish buff, crystalline dolomite with some gray dolomite; slow eff	20	245
White sandstone; rounded, colorless quartz grains embedded in a matrix of white dolomite—characteristic; some fragments of dolomite	15	260
Sandy, dark brownish gray and white dolomite	15	275
Bluish gray, dolomitic shale, or very argillaceous dolomite, and gray dolomite, very pyritic in places; slow eff	15	290
Dark and light gray, fine grained, argillaceous dolomite, and gray dolomite; slow eff.; very pyritic in places	35	325
St. Peter sandstone:		
Pure white sandstone, some fragments of dolomite	40	365
White to yellowish gray and white dolomite, very sandy in places	35	400

	Thickness, feet.	Depth, feet.
Beekmantown or "Calciferous" sandstone:		
White dolomite and some dark red shale and argillaceous dolomite, slow eff.; some rounded white quartz sand	20	420
Jordan sandstone—Pure white sandstone with some dolomite near the top	40	460
St. Lawrence:		
Gray sandstone and sandy dolomite	70	530
Gray sandstone with some sandy dolomite. Rounded colorless quartz grains embedded in the dolomite	20	550
Very white sandy, crystalline dolomite	10	560
Lake Superior or Potsdam sandstone:		
Pure white sandstone	20	580
Grayish white sandstone; rounded, colorless quarts grains	20	600
Pure white sandstone	60	660
Greenish white sandstone	40	700
White sandstone	60	760
Reddish white sandstone, most grains stained yellow or red	15	775
Light brick red quartzite and white sandstone. Evidently the sample at 795 was from the top of the Pre-Cambrian quartzite	20	795
Pre-Cambrian (Huronian [?]):		
Jaspilitic arkose, quartzite of various shades of red with white mica, pyrite, feldspar, etc. Locally much stained, colored by iron oxide. Artesian water struck at 860 feet	183	978

MIDLAND COUNTY.

Sanford. A well 400 feet in depth was drilled at Sanford to secure an adequate supply of water for the proposed State Sanitorium for Tuberculosis. In the first well there were no fresh water-bearing strata in the surface deposits or in the bed rocks below. A little salt water was encountered below 228 feet. A second well 400 feet from the first was drilled to the depth of 245 feet. These and other wells indicate that the underground supplies of fresh water in the vicinity of Sanford are limited.

SANFORD SANITORIUM WELL NO. 1.

Location: Near site of proposed State Sanitorium for Tuberculosis, Sanford, Midland Co., T. 15 N., R. 1 W. Drilled in 1914. Record furnished by Dr. E. B. Pierce, Superintendent of Michigan State Sanitorium at Howell.

Elevation about 620 A. T.

	Thickness, feet.	Depth feet.
Pleistocene or glacial depth:		
Sand	5	5
Clay	46	51
Hardpan	175	226
Saginaw Coal Measures:		
Shale	2	228
Sandrock and shale 1% brine	108	334
Depth of well	....	400

Test well No. 2 was driven to the depth of 245 feet, 400 feet from the first, with similar results.

OAKLAND COUNTY.

Avon Township. D. M. Ferry and Co. drilled a number of test wells for water on their seed farm near Rochester. The surface deposits contained only very thin beds of sand and gravel, yielding but a scanty supply of water. The deepest well penetrated rock and struck brine in the Berea sandstone. A suitable supply of fresh water was found in the drift by directing exploration northwest from the farm toward the morainic country.

D. M. FERRY & Co. WELL NO. 1.

Location: Center-south, Section 23, Avon Twp. (T. 3 N., R. 11 E.) Oakland Co. Drilled Sept. 1912, by O. N. Phillips, Troy, Contractor for D. M. Ferry Co. of Detroit. Record furnished by O. N. Phelps.

Elevation about 760 feet.

	Thickness, feet.	Depth feet.
Pleistocene or glacial deposits:		
Sand	7	7
Blue clay	121	128
Fine sand streaked with hard pan	10	138
Sand hardpan	27	165
Coldwater shale:		
Blue shale	15	180
Black shale and slate rock	45	225
Water shales	5	230
Berea sandstone:		
Sandstone	50	280
Antrim shale:		
Gray shale	95	375

OTTAWA COUNTY.

Zeeland. A test well for water was drilled in 1913 for the village of Zeeland. Very little water was found in the drift and brine was struck in the Coldwater shale below. Zeeland is near the feather edge of the Marshall sandstone. In a later well, water was struck in considerable quantity in an outlier of Marshall sandstone southwest of the village. The record below was compiled from a sketch furnished by the W. J. Sherman Co. of Toledo.

ZEELAND MUNICIPAL WELL NO. 1.

Location: Zeeland, Michigan. R. 14 W. T. 5 N. Copied by W. J. Sherman Co., Toledo, Ohio, from sketch furnished by village authorities December, 1913.

	Thickness, feet.	Depth feet.
Pleistocene or Glacial Drift:		
Yellow sand	1.5	1.5
Yellow clay	5.5	7
Tough blue clay	5	12
Clay and sand mixed	28	40
First water at 40 feet.		
Sand hard pan with large boulders	20	60
Sand hard pan	65	125
Seam of water sand 125 feet.		
Sand hard pan	25	150
Water sand at 150 feet.		
Sand hard pan with large boulders	50	200
Clay hard pan	2	202
Coldwater shale:		
Shale rock	291	493
Brownish rock with mica	2	495
Gray lime rock	45	540
Brine—60% salt at 540 feet.		
Gray lime rock	37	577
Shale at 577 feet.		

ROSCOMMON COUNTY.

Roscommon. Franz Jahncke began a test well for oil at Roscommon for Walker and Bell of Alpena. At a depth of 874 feet the well was abandoned. A record was furnished the Survey by Mr. Jahncke. The Marshall sandstone was 125 feet thick and yielded a large flow of artesian water.

ROSCOMMON WELL.

Location: Roscommon, Roscommon County. Drilled in 1914 for Walker and Bell Company by Franz Jahncke of Alpena, Mich.

Elevation about 1,125 ±.

	Thickness, feet.	Depth feet.
Pleistocene or surface deposits:		
Mostly sand and gravel; no gypsum or sharp cornered lime rock in the drift	417	417
Michigan Series:		
Soft sand rock	8	425
Black limestone, big flow of mineral water	0–6″	425–6″
Hard gray blue rock, very sharp; one bit would not drill more than 10 inches or a foot	59–6″	485
Blue Shale	63	548
Upper Marshall:		
Sand rock, micaceous toward bottom	125	673
Big flow of water at 550 ft., rising 7 ft. above surface.		
Lower Marshall and Coldwater—Blue shale full of gas	201	874

ST. CLAIR COUNTY.

Port Huron. In 1916 the Morton Salt Co. formerly the Port Huron Salt Co. drilled a deep well for salt of which a careful log and a complete set of samples were preserved for the Survey. The following is the record as compiled from the drillers' log and samples. The samples were taken every five feet. This made it possible to draw the line of separation between the Dundee limestone and the Monroe formation within very narrow limits. The samples from this well and the wells at Dearborn and Highland Park, Wayne county, show that in southeastern Michigan the Dundee limestone has a thickness varying from about 100 feet in the vicinity of Detroit to 125 feet at Port Huron.

MORTON SALT CO. WELL NO. 11.

Location: At Plant, southern part of the city of Port Huron. Well began May 15, 1916; completed Sept. 9, 1916. Drilled by Brogan Drilling Company, Port Huron. Record by R. A. Smith from a complete set of samples and data furnished by Morton Salt Co. through C. A. Sotherland. Samples every 5 feet from depth of 167 feet.

Elevation 24-25 feet above St. Clair River or about 604 feet. A. T.

	Thickness, feet.	Depth feet.
Pleistocene or surface deposits:		
Drift with 2 ft. of gravel with water 14 ft. 4 in. of 12 in. pipe	12-2′	12-2′
Clay with 2 ft. of sand and gravel in bottom of clay, struck gas but pipe shut it off. Rock at 134 feet. Put in 132 ft. 5 in. of 10 in. drive pipe	121-10′	134
Antrim shale:		
Grayish and brownish black shale, very pyritic in places and very black at 247 ft	168	302
Lots of gas from black shale crevice at 190 ft. Shale very hard in bottom from about 182 to 222 feet		
Traverse formation:		
Gray argillaceous limestone; violent effervescence	10	312
Gray and buff limestone, hard limestone from 321 feet to 400 feet, viol. eff	15	327
Hard limestone and streaks of gray very calcareous shale—soapstone; viol. eff	25	352
Hard gray to buff and brownish limestone with streaks of shale	40	392
Gray calcareous shale, some limestone	8	400
Gray and buff to dark bituminous limestone with some shale; viol. eff	12	412
Dark gray calcareous and fossiliferous shale; some limestone at 510 and 515 ft	125	537
Dark bituminous crystalline limestone, viol. eff., some shale	5	542
Bell shale:		
Dark gray shale, fossilferous; viol. eff	58	600
Dundee (Onondaga) limestone:		
Dark buff and bituminous limestone; viol. eff. Some shale apparently from above	7	607
Light buff and buff limestone, viol. eff. Hard and slow drilling, crevice, black water, and gas at 640 feet	35	642
Dark gray and buff limestone, viol. eff	5	647
Gray to buff limestone, brown and bituminous in places, viol. eff	85	732
Upper Monroe or Detroit River Series:		
Buff dolomite, slow eff	20	752
Buff and brown to black bituminous dolomite with shaly streaks; slow effervescence	5	757

	Thickness, feet.	Depth feet.
Buff dolomite, sandy; slow eff. Numerous small colorless grains of quartz in places. Much black bituminous matter in streaks and partings	30	787
Gray and buff dolomite with streaks of black bituminous and gray shaly matter; slow eff	30	817
Grayish black very bituminous dolomite, slow eff. Some buff and gray dolomite	20	832
Buff and gray dolomite with much anhydrite	10	842
Buff to dark buff bituminous dolomite, slow eff. Wet hole and at 918 feet hole was full of water	10	852
Dark buff and brown very bituminous dolomite slow eff. "Wet hole"	15	867
Buff to dark buff bituminous dolomite; slow eff	10	877
Buff dolomite and anhydrite, slow eff	5	882
Light buff to grayish buff fine grained dolomite, a little gypsum at 928 feet, slow eff. Hole full of water from 918 ft. down to 1,393 ft. 10 in. Put in 1,393 ft. 6 in. of 6¼ inch casing with packer	65	947
Gray fine grained shaly dolomite; slow eff	5	952
Light buff fine grained dolomite, slow eff	5	957
Gray to dark gray shaly dolomite and shale, slow eff	40	997
Dark brownish gray and dark brown bituminous dolomite, very argillaceous in places	60	1,057
Limestone very "sharp" at 1,033 ft. Oil at 1,007 feet.		
Hard dark gray to grayish black and brown dolomite, argillaceous in places	25	1,082
Dark gray argillaceous dolomite	10	1,092
Dark gray and buff argillaceous dolomite, close grained and very argillaceous or shaly in places	35	1,127
Very hard buff to dark buff fine grained dolomite; bluish at 1,170 ft. Cherty from about 1,176 to 1,182 feet	55	1,182
Hard buff dolomite with anhydrite	15	1,197
Dark gray argillaceous dolomite	5	1,202
Gray to buff dolomite and much anhydrite. "Sharp" or hard granular dolomite at 1,210 feet	35	1,237
Gray argillaceous to very argillaceous dolomite. Twelve feet of hard "blue lime" 1,267 to 1,279 feet. Cherty at 1,275 feet	45	1,282
Dark gray shale	5	1,287
Light colored dolomite	10	1,297
Dark gray shale and shaly dolomite	5	1,302
Light buff dolomite	5	1,307
Dark gray shale	5	1,312
Dark gray shaly dolomite	5	1,317
Light colored dolomite	10	1,327
Gray shale and shaly dolomite	5	1,332
Light to buff dolomite	5	1,337
Gray shale and shaly dolomite	5	1,342
Light to buff dolomite, with dark gray shale at the bottom	20	1,362
Dark gray shale, some dolomite and anhydrite ($CaSO_4$)	20	1,382
Gray shaly dolomite	10	1,392
Dark gray shale and shaly dolomite	5	1,397
Black bituminous shale and shaly dolomite	5	1,402
Buff to gray dolomite	5	1,407
Chiefly buff dolomite. Struck brine at 1,421 feet which tested 90 per cent	15	1,427
Dolomite and much anhydrite ($CaSO_4$)	25	1,452
Buff dolomite, gray shale, and some anhydrite	10	1,462
Gray argillaceous dolomite, in places shaly, some anhydrite. "Bottom of blue limestone"	53	1,515
Salina:		
White salt with some streaks of shale	15	1,530
White salt	55	1,585
Anhydrite, shale, and salt	5	1,590
White salt. "Bottom of salt." (Other beds of salt occur below this depth—S.)	6–4"	1,596–4"
Dolomite	4	1,600–4"
Casing: 52 feet 7 inches of 12-inch drive pipe, 132 feet 5 inches of 10-inch pipe, 1,396 feet 10 inches of 6¼-inch casing; 1,597 feet 6 inches of 3 and 3½-inch tubing and 561 feet 5 inches of air line.		

North Port Huron. In 1915 the Michigan Central Oil and Mining Co. of Port Huron drilled an oil well on the low ground on the north side of Black River about two miles west of North Port Huron. This well is the most northerly of the oil wells drilled in the Port Huron anticline. No oil or gas was reported but it is probably that oil and gas were struck in small quantities similar to the wells on the south side of the river on the May and Gillette farms as described in Publication 19, Mineral Resources of Michigan for 1914.

OXBOW WELL NO. 1.

Location: On the Oxbow of Black River a few rods north of the river channel, near S. E. corner N. W. ¼ sec. 32, T. 7 N., R. 17 E. Drilled in 1915 by Michigan Central Oil & Mining Co., Port Huron. Record by R. A. Smith from samples furnished by C. M. VanCuren, Pres., and G. W. VanCuren, Manager of the company.

Elevation about 586 ft. A. T.

	Thickness, feet.	Depth feet.
Pleistocene or surface deposits:		
River silt and clay	70	70
Coarse gravelly sand, very dark from fragments of black shale, shale particles angular	35	105
Antrim shale:		
Black bituminous and pyritic shale	105	210
Black pyritic shale and buff to gray limestone; mod. eff	5	215
This screw apparently penetrated the Traverse about 2 ft.		
Traverse (Hamilton) formation:		
Hard, fine grained buff magnesian limestone; mod. eff	6	221
Record missing	20	241
Gray and grayish buff limestone; vig. eff	9	250
Record missing	280	530
Soft blue gray calcareous shale or soapstone (Marcellus); vig. eff	10	540
Dundee (Onondaga) limestone:		
Dark gray limestone; viol. eff	2	542
Dark gray very pyritic limestone; viol. eff	4	546
Light buff crystalline limestone; viol. eff	16	562

WAYNE COUNTY.

Dearborn. In 1915 Henry R. Ford drilled a well at Dearborn, Wayne county, largely for scientific purposes. The well as planned was to be 5,000 feet deep or down to the "granite" or pre-Cambrian rocks. The well was begun June 14, 1915, and by the middle of October it was down to 4,035 feet, when the drill wedged in a crevice, breaking the cable. After several months of vain effort to recover the tools, the well was abandoned. This is the deepest well in the state, being over 350 feet deeper than the deep well at Mt. Pleasant, Isabella county.

A careful log and duplicate sets of samples were preserved, one set for the State Survey and the other for Mr. Ford. The samples were taken every five feet and with the log afford detailed information concerning the character, thickness, and depth of the rock strata down nearly to the Cambrian. The Mt. Pleasant well ended in the top of the Dundee (Onondaga) limestone at a depth of 3,680 feet and the Dearborn well began in the top of this formation. The two wells thus give a complete section of the Paleozoic rocks nearly down to the Cambrian.

The most important facts shown by the record are the exceptional aggregate thickness of the rock salt beds, the presence of about 300 feet of gypsiferous and celestitic rocks below the salt bearing horizons, the thinness of the "Niagara," and the exceptional thickness of the so-called "Trenton" limestone.

The salt beds at Dearborn have an aggregate thickness of over 550 feet in a section of 870 feet. In the Royal Oak well, over 600 feet of salt was penetrated in a section of 932 feet. These thickennesses are much greater than farther east along Detroit River and indicate that the salt beds extend a considerable distance northwest toward the center of the state.

In most of the earlier records of wells drilled in southeastern Michigan, the line separating the Salina from the "Niagara" was drawn near the base of the salt bearing horizon. At Dearborn and also at Highland Park, the strata are dark, bituminous, shaly dolomite simliar to the Monroe beds above the Salina. Moreover, the beds are brecciated and locally contain an abundance of gypsum and celestite, the latter being most abundant in the cavities of the breccias.

The removal of these beds from the "Niagara" limestone leaves this formation very thin in southeastern Michigan; it is about 90 feet thick at Dearborn. The record of the Ford Motor Co. well at Highland Park, Detroit, indicates a similar thickness.

In the Northern Peninsula the "Trenton" has a maximum thickness of about 270 feet and is to be directly correlated with the Galena and Platteville limestones of Wisconsin. In southeastern Michigan the Trenton has an average thickness of over 850 feet as shown by the Dearborn and the LaSalle (Monroe county) wells, and is to be correlated with the Ontario rather than the Wisconsin section. According to Ulrich most of the "Trenton" in southeastern Michigan is probably Black River.

No oil or gas was found at any horizon. An abundance of sulphuretted water was struck just above and in the top of the Dundee, and much sulphate water down to the bottom of the Sylvania sandstone. Below this there was very little water until the St. Peter sandstone was reached.

The following is an illustrated record of the Dearborn well.

Highland Park. A few years ago the Ford Motor Company drilled a test well for water near their plant in Highland Park, Detroit. A complete set of samples was preserved from which a duplicate set was made for the Survey. Apparently no log was kept and the following is a detailed record made from the samples:

FORD MOTOR CO. WELL.

Location: 48 ft. 4 in. south of north property line and 6 ft. 3 in. west of West Brush St. line of Ford Motor Co., Woodward Ave., Highland Park, a suburb on the north side of Detroit. Drilled in 1913. Record by R. A. Smith from samples furnished through W. H. Smith of the Ford Motor Company. Record down to 230 ft. is based on general geological data.

Elevation about 633 ft. A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Sand and sandy clay	25+	25+
Clay with some intercallated beds of sand and gravel	115 ±	140 ±
Antrim (Genesee) shale—Black bituminous shale	60 ±	200 ±
Traverse (Hamilton) formation:		
Limestone and calcareous shale or "soapstone" probably	30	230
Soapstone or soft gray, highly calcareous shale; vig. eff. with cold dilute hydrochloric acid. Fossiliferous (athyris) between 270 and 280 ft	70	300
Hard gray limestone, some gray shale or soapstone, viol. eff	5	305
Hard gray, crystalline limestone, viol. eff	5	310
Bell (Marcellus) shale:		
Soft highly calcareous, light gray shale or "soapstone," very smooth grained	40	350
Dundee (Onondaga) limestone:		
Hard, light gray, crystalline limestone; vig. eff. Sample 350 to 355 badly rusted	10	360
Hard, white to light gray and buff gray and buff, crystalline limestone with dar[illegible] and black streaks and laminae of bituminous matter. Viol. eff. 2 to [illegible] white sand, grains very rounded in sample 470 to 475 feet	115	475
Very hard crystalline, light gray, pyritic and sandy limestone, vig. eff. to to viol. [illegible]y very small crystals of pyrite and 5% or more of pure white quartz sand with rounded grains of uniform size similar to the Sylvania	5	480
Buff, bituminous and white to light grayish buff limestone. Buff limestone is very sandy appearing but contains very little sand; viol. eff. Crinoidal from 485-490 ft	10	490
Upper Monroe dolomites or Detroit River Series:		
Chiefly white, earthy looking dolomite with fine laminae of pyritic and black bituminous matter; slow eff. A little buff, bituminous limestone apparently from Dundee above, vig. eff. cf. H. R. Ford well, Dearborn at 220 ft	5	495
Buff, bituminous limestone and native sulphur	10	505
White, light gray and buff bituminous limestone and native sulphur	5	510
Light gray dolomite; mod. eff	5	515
Light gray to buff dolomite; mod. to brisk eff	5	520
Light, grayish buff to dark buff dolomite and dolomitic limestone; slow to brisk eff. Some dark gray shale. Eff. with fine powder seems to be due to crystals of calcite in geodes and seams	10	530
White and buff dolomite and dolomitic limestone. Slow to brisk eff	5	535
Hard, buff, granular dolomite and dolomitic limestone; slow eff. to moderate eff	5	540
Hard, light buff dolomite; slow to mod. eff	15	555
Buff, bituminous dolomite; slow eff	15	570
White and light buff dolomite; slow eff	5	575
Light buff and buff dolomite and some black shale; slow eff	5	580
Light buff dolomite, pure white anhydrite and gypsum—apparently cleavage plates of selenite	5	585
Light buff to buff dolomite and much pure white anhydrite; slow eff	15	600
Dark buff dolomite; slow eff	5	605
Light buff dolomite, slow eff	5	610

	Thickness, feet.	Depth, feet.
Chiefly white dolomite, some light buff; slow eff	10	620
Light gray, earthy looking dolomite; slow to moderate effervescence	5	625
Buff crystalline dolomite; slow to mod. eff	5	630
Light buff, crystalline dolomite, sandy about 5% of pure white quartz sand, grains rounded, slow to mod. eff	15	645
White and very light buff, dense grained dolomite, slow to mod. eff	10	655
Light buff dolomite	5	660
Buff gray, argillaceous dolomite with streaks and laminae of black bituminous shale, slow eff. Considerable residue of clay	5	665
Light buff and white, finely crystalline dolomite, mod. eff	15	680
Light buff dolomite and pure white anhydrite—25% anhydrite	10	690
Light, grayish buff, fine grained dolomite with black, bituminous laminae	5	695
Very light gray, grayish buff and white dolomite; mod. eff	5	700
Buff dolomite with black bituminous streaks and soft white chalky limestone, the latter viol. eff	5	705
Dark grayish buff, dolomitic limestone; moderate to brisk effervescence	5	710
Grayish buff limestone; vig. to viol. eff. The limestone from about 705-730 ft. may be the Anderdon beds	5	715
Buff limestone with much white chalky limestone, viol. eff	5	720
Light buff limestone; viol. eff	5	725
Light buff to buff limestone, viol. eff., and dark buff bituminous dolomite, slow eff	5	730
Dark buff gray dolomite and some light buff limestone, the first slow eff.—latter viol. eff	5	735
Sample from 735 to 745 missing—very probably dolomite	10	745
Grayish buff dolomite and considerable shaly, white limestone, the latter viol. eff	5	750
Grayish buff dolomite and dolomitic limestone; brisk eff	25	775
Buff gray dolomite; brisk eff	10	785
Sylvania sandstone or Middle Monroe:		
Pure white sandstone of uniform sized grains of white or colorless quartz—a glass sand. A little admixture of buff dolomite from above	5	790
Pure white sandstone—sample badly rusted from fragments of the drill	30	820
White dolomitic sandstone; slow eff. 80% pure white quartz sand	5	825
Pure white sandstone	25	850
Pure white sandstone and gray sandy dolomite	5	855
Gray sandy dolomite—pure white rounded sand grains embedded in a dolomitic matrix	5	860
Lower Monroe or Bass Island Series:		
Hard, light gray dolomite; mod. to brisk eff. Some white chalky limestone, viol. eff	20	880
Light gray and very white crystalline dolomite, slow to mod. eff	5	885
Grayish buff to dark gray, argillaceous dolomite, some pure white chert	15	900
Gray dolomite with white chalky limestone, the latter vig. eff. Chalky material apparently from cavities and seams	10	910
Light grayish buff dolomite	10	920
Light gray and gray dolomite, slow eff	10	930
Grayish buff dolomite with considerable pure white, crystalline dolomite, apparently from geodes	5	935
Light buff dolomite, slow eff	5	940
Samples missing from 940 to 955 feet	15	955
Light buff and gray dolomite	10	965
Light buff dolomite	20	985
Very light buff, fine grained dolomite, mod. eff	5	990
Light buff, dense grained dolomite	15	1,005
Very light grayish buff, dense grained dolomite	10	1,015
Buff, dense grained dolomite with bituminous streaks and laminae	10	1,025
Light buff, dense grained dolomite. Insoluble residue of 10% of bituminous and argillaceous matter and pure white quartz sand, the latter probably from the Sylvania above. Very slow eff	15	1,040
Gray, shaly dolomite with thin streaks and laminae of dark to black bituminous matter, slow eff. Considerable insoluble residue of clay and bituminous matter	5	1,045
Chiefly buff, dense grained dolomite with some gray and dark bituminous streaks and laminae, slow eff	5	1,050
Hard, buff gray dolomite, considerable clay residue, slow eff	5	1,055
Grayish to dark buff and brown bituminous dolomite	5	1,060
Light gray dolomite, some dark buff and brown, slow eff	5	1,065

	Thickness, feet.	Depth, feet.
Salina (?) formation:		
Pure white salt. This sample is apparently out of place. There is not the slightest trace of salt in the samples preceding or in the samples immediately following this one and some salt should certainly be found in the samples from 1,070 to 1,075	5	1,070
Buff gray to dark grayish buff and brown, bituminous and argillaceous dolomite, slow eff	5	1,075
Chiefly grayish buff dolomite with black, bituminous streaks and laminae, slow eff	5	1,080
Light buff to buff dolomite and gray shaly dolomite, some dark bituminous laminae, slow eff	10	1,090
Light grayish buff, dense grained dolomite, argillaceous, slow eff	25	1,115
Light buff and gray and dark buff and brown bituminous dolomite	5	1,120
Gray, shaly dolomite, some buff dolomite with bituminous streaks and laminae, and considerable white anhydrite and gypsum	5	1,125
Dark buff, bituminous dolomite with white seams of crystalline dolomite; slow eff	5	1,130
Gray to dark gray, shaly and light buff dolomite and white anhydrite, slow eff. Large clay residue, considerable bituminous matter	10	1,140
Gray, very shaly dolomite and much white anhydrite and gypsum	5	1,145
Dark gray shale and some white anhydrite	10	1,155
Chiefly white anhydrite, some light buff dolomite	5	1,160
Light buff to buff, very dense grained dolomite, very thinly bedded	10	1,170
Buff to dark buff, bituminous and very dense grained dolomite, very thin bedded	5	1,175
Very light buff dolomite and white anhydrite, dolomite very thin bedded, largely precipitate of barium sulphate	5	1,180
Gray dolomite	5	1,185
Grayish buff and dark gray, bituminous dolomite, slow eff	10	1,195
Gray and buff dolomite and anhydrite	15	1,210
Gray shale, buff and gray, shaly dolomite, and some anhydrite	10	1,220
Chiefly gray shale, some gray shaly dolomite	15	1,235
Gray, shaly dolomite	5	1,240
Dark gray shale and gray argillaceous dolomite	10	1,250
Buff gray dolomite and gray shale	15	1,265
Salina formation:		
White salt with a little dolomite and shale probably from above. Strong flame coloration for potassium on samples 1,265 to 1,275, weak from clear salt samples. Flame test for potassium, using a Merwin triple screen for flame reactions, was run on all of the samples of salt and of the shale and dolomite immediately above each salt bed. Strong flame colorations were given almost uniformly by the shale and shaly dolomite and also by the impure salt, i. e., the salt mixed with shale and shaly dolomite. The solutions made from the samples of clear salt and also those of shale and dolomite gave only faint flashes of color. The flame colorations apparently were due to potassium compounds in the shale and shaly matter and not to free potash salts in the salt beds	40	1,305
White salt and considerable shale with some anhydrite, apparently a streak of shale	5	1,310
White salt, chiefly with a little admixture of shale and dolomite	10	1,320
Yellowish white salt with much buff dolomite, some anhyrdite	5	1,325
Argillaceous dolomite and anhydrite	5	1,330
Argillaceous dolomite, bright potassium flame	5	1,335
Chiefly white salt, some dolomite and shale	10	1,345
Clean, white salt, stained yellow with rust from the drill	45	1,390
White salt and anhydrite	5	1,395
Gray shale, dolomite and anhydrite	5	1,400
Chiefly anhydrite, some shale and dolomite	5	1,405
Sample missing	5	1,410
Chiefly buff dolomite and gray shale	5	1,415
Buff dolomite, gray shaly dolomite, and much white anhydrite	5	1,420
Buff dolomite and gray shale	5	1,425
Clean, white salt	20	1,445
Sample missing	5	1,450
Chiefly anhydrite and salt, some buff dolomite	10	1,460
Chiefly white salt, some anhydrite and dolomite	5	1,465
Sample missing, probably salt	5	1,470
Clear white salt	5	1,475
Sample missing, probably salt	10	1,485
White salt	10	1,495
Salt, anhydrite and dolomite	5	1,500
White salt	5	1,505
Soft buff dolomite, bituminous, slow eff	10	1,515

	Thickness, feet.	Depth, feet.
Buff dolomite and considerable anhydrite	10	1,525
Buff dolomite and gray shale and shaly dolomite, slow eff	5	1,530
Chiefly white salt, some shaly dolomite and shale	5	1,535
Clean white salt	15	1,550
Sample missing, probably salt	5	1,555
White salt	5	1,560
White salt and gray shale	5	1,565
White salt, a very little gray shale at 1,570 ft., the latter an admixture from above	50	1,615
White salt and gray shale	5	1,620
Gray shale, a little white anhydrite	5	1,625
Chiefly gray dolomitic shale and a little light buff dolomite	5	1,630
Very light buff dolomite and white anhydrite, some gray shale	15	1,645
Light buff dolomite and some dark gray and black shale	5	1,650
Chiefly gray shale, some light buff dolomite	5	1,655
Buff dolomite and gray shale with some anhydrite	15	1,670
Buff to dark buff dolomite and dark gray to black bituminous shale	10	1,680
Buff dolomite, gray shale and anhydrite	5	1,685
Chiefly light buff dolomite and some dark bituminous dolomite, a little anhydrite	10	1,695
Buff, granular dolomite with fine black, bituminous laminae	10	1,705
Light to dark buff dolomite	5	1,710
Light buff to buff, brecciated dolomite with clay cement, dark bituminous streaks	5	1,715
Light to dark buff, bituminous dolomite, slow eff	15	1,730
Clean white salt	5	1,735
White salt with a little dolomite and shale	25	1,760
Light buff to buff dolomite	5	1,765
Buff dolomite, gray argillaceous dolomite, gray shale, and anhydrite	50	1,815
Light buff and gray dolomite, gray shale and much anhydrite	5	1,820
Sample missing, probably similar to sample above	5	1,825
Light buff and gray dolomite, gray shale and much white anhydrite	5	1,830
White salt with considerable gray shale and gray and buff dolomite	5	1,835
Clean white salt	10	1,845
Sample missing, probably salt	5	1,850
Clean white salt	10	1,860
Sample missing, probably salt	5	1,865
White salt and considerable dolomite and shale	5	1,870
Buff dolomite and white salt	5	1,875
Sample missing	5	1,880
White salt	5	1,885
Sample missing	5	1,890
Buff dolomite, gray shale, anhydrite and salt	5	1,895
White salt, dolomite and anhydrite	5	1,900
Chiefly white salt, some dolomite, apparently from above	5	1,905
Sample missing, probably salt	5	1,910
White salt	15	1,925
Sample missing, probably salt with more or less dolomite, shale and anhydrite.	35	1,960
Chiefly white salt (some of the samples badly rusted, difficult to determine natural color of salt)	15	1,975
White salt with a little shale and dolomite	5	1,980
White salt, shale and dolomite	10	1,990
Chiefly white salt, a little shale and dolomite	20	2,010
Sample missing	5	2,015
Clean white salt	5	2,020
White salt with a little shale and dolomite	10	2,030
Nearly clear white salt	10	2,040
Chiefly salt, some shale, anhydrite and dolomite	5	2,045
Clean salt	5	2,050
White salt with some shale and dolomite	10	2,060
Clear white salt	5	2,065
Sample missing, probably salt	5	2,070
Clean white salt	5	2,075
White salt, dolomite and shale	5	2,080
Nearly clean white salt, salt stained by rust from drill	5	2,085
White salt, buff dolomite, shale and some anhydrite	10	2,095
White salt	5	2,100
Sample missing, probably salt	5	2,105
White salt	10	2,115
Buff to dark buff dolomite and salt, dolomite bituminous	5	2,120
Buff to dark buff and brown, bituminous dolomite, some anhydrite in sample from 2,120 to 2,125	15	2,135
Gray shale and buff dolomite, some white anhydrite	5	2,140
Buff to dark buff dolomite, with bituminous streaks and laminae	30	2,170

	Thickness, feet.	Depth, feet.
Chiefly dark buff and grayish brown dolomite, argillaceous	5	2,175
Buff dolomite with anhydrite and some gray shale	5	2,180
Buff to dark buff dolomite	15	2,195
Dark buff, bituminous dolomite or dolomitic limestone, very argillaceous in places, vig. eff. From 2,195 to 2,275 ft. and 2,315 to 2,395 ft. there is more or less limestone or dolomite with much calcite from drusy cavities and seams	45	2,240
Sample missing	5	2,245
Dark gray, bituminous and agrillaceous dolomite or dolomitic limestone and light gray dolomite or dolomitic limestone, vig. eff	5	2,250
Gray, calcareous shale, vig. eff.—some dark, dolomitic limestone	5	2,255
Sample missing	5	2,260
Gray, calcareous shale and light buff and buff gray, fine grained, dolomitic limestone; vig. to viol. eff	5	2,265
Chiefly dark buff, bituminous, dolomitic limestone, very dense grained and thin bedded, breaks up into thin plates, some light buff; vig. eff	10	2,275
Light to dark buff dolomite, dark gray shale and shaly dolomite, white anhydrite and celestite, slow to mod. eff. Bituminous	15	2,290
Chiefly white celestite and anhydrite, some dolomite, nearly pure white anhydrite and celestite 2,300 to 2,310 ft., considerable dolomite in sample 2,310 to 2,315. Strong reaction for strontium	25	2,315
Buff to dark buff and brown bituminous dolomite, very dense grained and thin bedded, vig. to viol. eff. With acid gives a strong smell of petroleum and large residue of bituminous matter	15	2,330
Buff, bituminous, dolomitic limestone, very dense grained and thin bedded. With acid gives strong smell of petroleum. Vig. to viol. eff. moderate eff., 2,350 to 2,355 ft	25	2,355
Buff, dolomitic limestone and a little anhydrite, vig. eff	15	2,370
Buff, dolomitic limestone apparently. Sample wet and very badly rusted	5	2,375
Dark buff, bituminous dolomite, slow to mod. eff	20	2,395
Guelph (Upper Niagaran) dolomites:		
White to very light gray and very light buff, crystalline dolomite with some dark buff, bituminous dolomite; mod. eff	40	2,435
Most of the samples badly rusted, original color hard to determine.		
Chiefly white to very light buff crystalline dolomite	5	2,440
White to light buff dolomite and considerable buff to dark buff dolomite	10	2,450
Light to dark buff bituminous dolomite; mod. to vig. eff	5	2,455
Chiefly white and light buff dolomite; mod. eff. Samples wet and badly rusted	10	2,465
White, light buff and buff crystalline dolomite, slow eff. Samples badly rusted.	5	2,470
White, light to dark buff, crystalline dolomite and blue shale	15	2,485
Light to dark buff crystalline dolomite	10	2,495

Detroit. The Federal Carbonic Co. drilled a comparatively shallow well in the northwestern part of Detroit for water. The record is indicative of the limited water possibilities in northern and northwestern Detroit.

THE FEDERAL CARBONIC CO. 5' WELL.

Location: Greenwood Ave. and G. T. R. R., Detroit, T. 1 S., R. 12 E. Drilled Dec., 1914, for the Federal Carbonic Co., Detroit, by E. S. Beal, Lansing, Mich. Record furnished by E. S. Beal from cores.

Elevation 42 feet above Detroit River or 617 ft. A. T.

	Thickness, feet.	Depth feet.
Pleistocene:		
Fill, yellow sand	12	12
Blue clay with small pebbles, very firm	30	42
Blue clay smooth with occasional sand pockets	60	102
Blue clay very gritty with limestone cobbles and boulders	40	142
Gravel, 35 ft. coarse, 11 ft. very fine. Dry all the way	46	188
Traverse formation:		
Limestone	4	192
Bell shale:		
Black shale, very fossiliferous with shining grains, pyrites of iron	9	201
Soft gray slate or shale, slacks on exposure to air	14	215
Hard gray slate, cores run from 8 inches to 3 feet long	24	239
Dundee (Onondaga) limestone:		
Blue limestone	7	246
White limestone very fossiliferous, numerous calcite seams. Small flows at 285 ft., 3 gallons per minute	45	291
Sandy limestone, very soft	11	312
Blue limestone, trace of oil and iron pyrites	12	324
Cherty limestone	4	328
Limestone, coral formation, very fossiliferous	9	337
Upper Monroe:		
Dolomite, gray, sharp grit and very hard	23	360
Dolomite, whitish, sharp grip and very hard	30	390
Small flows of water at 376 ft., water 30 ft. from surface, 6½ gals. per minute.		
Dolomite, yellow, sandy, soft	5	395

"Expected to get bed rock at this location at 120 to 140 feet but drilled through a 46 ft. deposit of gravel, dry all the way; found a short deposit of limestone at 188 to 192 ft. then ran into Bell shale and the gray slate down to the Dundee at 239, or 100 ft. below my estimate, showing a great depression at this location. Found the limestone very dense, no pockets or fractured rock and only two seams and they were very tight; small flow at 285 ft., 3 gals. per minute; small flow at 376 ft. in the dolomite. The water head stood at 35 ft. from surface and would flow 6½ gals. per minute.

Shot the well with 40 lbs of 60% dynamite; put in a 1½" air lift and a 2" discharge and blowed 14½ gals per minute. The water is very black and salty, showing oily substance on top and black sand on bottom after standing 2 hours."

Trenton. The records of some of the Church and Co. wells at Trenton were recently obtained from the U. S. Geological Survey and the record of the No. 4 well, the deepest, is given below. A record of the No. 5 well was published in Publication 14.

CHURCH AND COMPANY WELL NO. 4.

Location: Near plant of Church and Company in the northern part of the village of Trenton. Record from driller's log.

Elevation 580 (?) feet.

	Thickness, feet.	Depth feet.
Pleistocene or glacial drift:		
Clay and gravel	30	30
Dundee (Onondaga) limestone and probably Upper Monroe in the lower part:		
Hard brown limestone	70	100
Upper Monroe or Detroit River series:		
Gray limestone	25	125
Soft gray brown limestone	55	180
Dark brown limestone	100	280
Sylvania sandstone:		
Hard white sandstone	140	340
Brittle gray shale rock and white sandstone	95	435
Lower Monroe or Bass Island Series:		
Hard gray shale rock	115	550
Gray and brown limestone with gypsum (anhydrite) at the bottom	230	780
Salina:		
Gypsum and shale	220	1,000
Brown shale	90	1,090
Gypsum	55	1,145
Gypsum and shale	40	1,185
Salt	30	1,215
Salt shales	60	1,275
Shale	50	1,325
Gypsum	50	1,375
Shale	55	1,430

Redford. In 1914 two wells were drilled near the village of Redford for a municipal supply of water. There was no water in the surface deposits and only a little salt water in the bed rocks below. The local supplies of water appear to be very limited. Records of the borings were furnished the Survey by Caster Brothers, the well contractors. The record of the deeper well is given below.

REDFORD MUNICIPAL WELL NO. 1.

Location: Village of Redford, Wayne County, S. E. ¼ Sec. 9, T. 1. S., R. 10 E. Record furnished by Caster Brothers, drillers. Well drilled in latter part of 1914.

Elevation about 630 feet A. T.

	Thickness, feet.	Depth, feet.
Pleistocene or surface deposits:		
Sand	12	12
Clay	78	90
Antrim shale:		
Lime rock	90	180
Lime shale; no water at all	25	205
Sand rock; a little salt water at 213 feet	10	215
Traverse formation (?):		
Lime rock—dry	61	276
Light shale—dry	128	404
Lime rock—dry	8	412

APPENDIX.

DIRECTORY OF THE PRODUCERS OF NON-METALLIC MINERALS IN MICHIGAN, 1916.

BRICK AND TILE MANUFACTURERS, 1916.

Operators.	Office.	Works.
Allegan County:		
Allegan Brick Works (Fish & Fish)	Allegan	Allegan.
Zeeland Brick Co	Zeeland	Zeeland.
Barry County:		
Leonard, Wm	Delton	Delton.
Bay County:		
Michigan Vitrified Brick Co	Bay City	Bay City.
Berrien County:		
Mamer Brick Co	Benton Harbor	Benton Harbor.
Branch County:		
Reynolds & Sons, Lorenzo D	Quincy	Algansee.
Charlevoix County:		
East Jordan Clay Products Co	East Jordan	East Jordan.
Chippewa County:		
Rudyard Brick Works	Rudyard	Rudyard.
Dickinson County:		
Vulcan Brick Works	Vulcan	Vulcan.
Eaton County:		
American Sewer Pipe Co	Broad St., Akron, Ohio	Grand Ledge.
Baker Clay Co	Grand Ledge	Grand Ledge.
Grand Ledge Clay Products Co	Grand Ledge	Grand Ledge.
Emmet County:		
De Arment, C. A	Petoskey	Petoskey.
Genesee County:		
Gale Bros	Atlas	Atlas.
Scholl, L. J. & C. E	Clio	Clio.
McCann, Fred'k W	Gaines	Gaines.
Sharp, Frank	R. D. No. 1, Linden	South Mundy.
Flint Clay Products Co	Flint	....
Gladwin County:		
Korkoske, Christ	Gladwin	Gladwin.
Grand Traverse County:		
Traverse City Brick Co	Traverse City	Keystone.
Gratiot County:		
Ashley Tile Co	Ashley	Ashley.
Stevenson & Sons, David	Ashley	Ashley.
Lee, Chas	North Star	North Star.
Peet, C. D	North Star	North Star.
Lyle G. Smith & Fred Bernard	St. Louis	St. Louis.
Riverside Brick & Tile Co	Sumner	Sumner.
Hillsdale County:		
Jerome Brick & Tile Co	Jerome	Jerome.
Ingham County:		
Clippert, Spaulding & Co	Lansing	Lansing.
Ionia County:		
Van Der Heyden, Fred H	Ionia	Ionia.
Isabella County:		
Mt. Pleasant Brick & Tile Co	Mt. Pleasant	Mt. Pleasant.
Jackson County:		
Disque, Price P., Warden Michigan State Prison	Jackson	Jackson.
American Sewer Pipe Co	Akron, Ohio	Jackson.
Kent County:		
Grand Rapids Brick Co	Mich. Ave. and Fuller St., Grand Rapids	Grand Rapids.
Blanchard, Addison H	Sparta	Sparta.

BRICK AND TILE MANUFACTURERS, 1916.—*Concluded.*

Operators.	Office.	Works.
Lenawee County:		
Wilt, C. H.	Blissfield	Blissfield.
Britton Pressed Brick Co.	Ann Arbor	Britton.
Atkin, Wm. T.	Deerfield	Deerfield.
Ruff, Lewis	Jasper	Jasper.
Ellis, G. D.	Macon	Macon.
American Brick & Tile Co.	Morenci	Morenci.
Comfort, Albert A.	R. D., Tecumseh	Tecumseh.
Macomb County:		
Hartsig, Jacob	Warren	Centerline.
Hacker, Frank G.	Mt. Clemens	Clinton.
Gass, East	R. D. No. 2, Washington	Davis.
Warren Brick & Tile Works	Warren	Warren.
New Baltimore Brick & Tile Co.	New Baltimore	New Baltimore
Manistee County:		
Kujawske, Joseph	Oakhill	Oakhill.
Mecosta County:		
Nehmer, Wm. F.	Big Rapids	Big Rapids.
Midland County:		
Rilett & Herwig, J. W.	R. D. No. 3, Coleman	Coleman.
Monroe County:		
Meyer Bros.	Azalia	Azalia.
Maybee Brick & Tile Co.	Maybee	Maybee.
Angerer Clay Products Co.	Scofield	Scofield.
Strong, John & Co.	South Rockwood	South Rockwood.
Muskegon County:		
Holton Brick Co.	Muskegon	Holton.
Newaygo County:		
Stevens & Sons, Wm.	R. D., Grant	Grant.
Ottawa County:		
Zeeland Brick Co.	Zeeland	Zeeland.
Saginaw County:		
Parker-Lohmann Brick & Tile Co.	R. D. No. 10, Saginaw, W. S.	Saginaw, W. S.
Sperry Bros.	Paines	Paines.
Day, James	R. D. No. 8, Saginaw	Saginaw.
Day, Thomas	R. D. No. 3, Saginaw	Saginaw.
Saginaw Paving Brick Co.	1850 S. Jefferson Ave., Saginaw	Saginaw.
St. Clair County:		
Belknap & Phillips	Bell River Road, St. Clair	St. Clair.
Sanilac County:		
Croswell Brick Co.	Croswell	Croswell.
Sandusky Brick & Tile Co.	Sandusky	Sandusky.
Shiawasse County:		
Wolverine Brick Co.	Box 289, Corunna	Corunna.
Tuscola County:		
Hall, Chas.	Cass City	Cass City.
Wayne County:		
Daniel & Bro. Brick Co., Jacob	291 Clippert Ave., Detroit	Detroit.
Haggerty, John S.	1815 Dime Sav. Bk. Bldg., Detroit	Detroit.
McDonald & Son, John C.	707 Hammond Bldg., Detroit	Springwells.
Ajax Brick Co.	66 Buhl Block, Detroit	Detroit.
Bunte Bros. Tile Co.	Flat Rock	Flat Rock.
Clippert & Bro. Brick Co., Geo. H.	1960 Michigan Ave., Detroit	Springwells.
Clippert, Wm.	1960 Michigan Ave., Detroit	Springwells.
Mercier, Bryan, Larkins Brick Co.	Michigan Ave. and Lonyo Road, Detroit	Springwells.
Lonyo Bros.	613 Campbell Ave., Detroit	Springwells.
Porath Bros.	306 Free Press Bldg., Detroit	Springwells.
Springwells Brick Co.	1009 Hammond Bldg., Detroit	Springwells.
Wolf Brick Co., F. H.	1467 Central Ave., Detroit	Detroit.
Pewabic Pottery & Tile Co.	2161 Jefferson Ave., Detroit	Detroit.

SAND-LIME BRICK PRODUCERS, 1916.

Operators.	Office.	Works.
Genesee County:		
Flint Sandstone Brick Co	Flint	Flint.
Houghton County:		
Lake Superior Stone Brick Co	Calumet	Ripley.
Huron County:		
Sebewaing Sandstone Brick Co	Sebewaing	Sebewaing.
Jackson County:		
Jackson-Lansing Brick Co	Rives Junction	Rives Junction.
Kalamazoo County:		
South Michigan Brick Co	Kalamazoo	Kalamazoo.
Kent County:		
Grande Brick Co	Kalamazoo Ave., Grand Rapids	Grand Rapids.
Menominee County:		
Menominee Brick Co	Menominee	Menominee.
Oakland County:		
Rochester Brick & Sand Co	Rochester	Rochester.
Saginaw County:		
Saginaw Brick Co	321 N. Hamilton St., Saginaw	Saginaw.
Wayne County:		
Michigan Pressed Brick Co	Cor. Lawton Ave., and M. C. R. R., Detroit	Detroit.
Sibley Brick Co	Sibley	Sibley.
Flood & Hall	Foot of Jean St., Detroit	Detroit.

CEMENT PRODUCERS, 1916.

Operators.	Office.	Works.
Huron Portland Cement Co	1525 Ford Bldg., Detroit	Alpena.
Burt Portland Cement Co	Bellevue	Bellevue.
Peninsular Portland Cement Co	Cooley Block, Jackson	Cement City.
Michigan Portland Cement Co	Chelsea	Four Mile Lake.
Wolverine Portland Cement Co	Coldwater	Coldwater and Quincy.
New Aetna Portland Cement Co	412 Union Trust Bldg., Detroit	Fenton.
Omega Portland Cement Co	Jonesville	Mosherville.
Newaygo Portland Cement Co	Grand Rapids	Newaygo.
Peerless Portland Cement Co	Union City	Union City.
Wyandotte Portland Cement Co	1525 Ford Bldg., Detroit	Wyandotte.
Egyptian Portland Cement Co	Fenton	Fenton.

LIST OF MICHIGAN COAL MINES, LOCATION BY COUNTY, NAMES OF MANAGERS AND SUPERINTENDENTS.

Name of mine.	County.	Manager.	Address.	Superintendent.	Address.
Robert Gage Coal Co. No. 6	Bay	Chas. Coryell	Bay City	H. C. Lewis	Bay City.
Robert Gage Coal Co. No. 7	Bay	Chas. Coryell	Bay City	John Coryell	Bay City.
Beaver Coal Company	Bay	Chas. Coryell	Bay City	John Coryell	Bay City.
Wolverine Coal Mining Company No. 3	Bay	R. M. Randall	Saginaw	Alex Liddle	Bay City.
Wolverine Coal Mining Company No. 2	Bay	R. M. Randall	Saginaw	Alex Liddle	Bay City.
What Cheer Coal Mining Company No. 1	Bay	E. B. Foss	Bay City	Alex Jeffreys	Bay City.
Wolverine Mining Co.	Calhoun	C. A. Hervey	Albion		
American Sewer Pipe Co.	Eaton	Clyde H. Earl	Grand Ledge		
Pickens Mine No. 2	Eaton	Homer Pickens	Grand Ledge		
What Cheer Mining Company No. 2	Genesee	E. B. Foss	Bay City	Alex Jeffreys	Bay City.
Cedar River Coal Mining Company	Ingham	Thos. M. Jenkins	Williamston	Thos M. Jenkins	Williamston.
Robert Gage Coal Company No. 2	Saginaw	Chas. Coryell	Bay City	Richard Jenkins	St. Charles.
Bliss Coal Mining Company	Saginaw	John T. Phillips	Saginaw	John E. Evans	Saginaw. Swan Creek.
Banner Coal Mining Company	Saginaw	Wm. B. Carmichael	Saginaw Swan Creek	Jos. Skillcorn	Saginaw. Swan Creek.
Shiawassee Coal Mining Company	Saginaw	R. M. Randall	Saginaw	Thos. Westwood	Saginaw.
Pere Marquette Coal Company No. 3	Saginaw	R. M. Randall	Saginaw	R. Johnston	Saginaw.
Chappell and Fordney No. 2	Saginaw	R. M. Randall	Saginaw	Tim Hollis	Saginaw.
Caledonia Coal Mining Company No. 3	Saginaw	John Dagan	Saginaw	Geo. Theily	Saginaw.
Superior Coal Co.	Shiawassee	W. E. Evans	St. Charles	——— Evans	Owosso, R.F.D.
Wolverine Brick Co.	Shiawassee	Wm. Brooks	Detroit		Corunna.
Akron Coal Mining Company	Tuscola	Chas. Handy	Bay City (W. S.)	John Morris	Akron.
Handy Bros. Mining Co.	Tuscola	Chas. W. Handy	Bay City (W. S.)		

Hon. Duncan A. Reed, State Coal Mine Inspector, Flint, Michigan.

CLAY MINERS, 1916.

Operators.	Office.	Mine.
Barry County:		
Leonard, Wm	Delton	Delton.
Ontonagon County:		
Emmond, Wm. F	Rockland	Rockland.
Robinson Clay Products Co	1010 E. Market St., Akron, Ohio	Rockland.
Vogtlin, W. P	Rockland	Rockland.
Jeffs, F. A	Rockland	Rockland.
Wayne County:		
Geo. H. Clippert & Bro. Brick Co	Detroit	Springwells.

COKE PRODUCERS, 1916.

Operators.	Address.	Location of plant.	No. of ovens.	County.
Michigan Alkali Co	Wyandotte	Plant No. 2	30	Wayne.
Semet-Solvay Co	Syracuse, N. Y	Detroit	175	Wayne.

NATURAL GAS PRODUCERS, 1916.

Operator.	Address.
Benzie County:	
Gordon & Conklin	Beulah.
Hillsdale County:	
DeWitt, C. M	Osseo.
Macomb County:	
Hanekow, Mrs. Wm. H	Warren, R. F. D. No. 2.
Hartsig, Wm. L	Warren, R. F. D. No. 2.
Jacobs, Edward and Otto	Warren, R. F. D. No. 2.
Elwart, Franz	Warren, R. F. D. No. 2.
Oakland County:	
McClelland, James	Redford.
St. Clair County:	
Haas, H. G	Port Huron, 1615 Griswold St.
Michigan Central Oil, Gas and Mineral Co	Port Huron.
Michigan Development Co	Port Huron.
Stevens, H. Leroy	Port Huron.
Stock Co., G. B., Xylite Grease and Oil Co	Port Huron.
Mason, F. H	Port Huron, 2478 Military St.
Howe, Geo. W	Port Huron, 4008 Military St
Lawrence, Gillett	Port Huron.
May, Henry	Port Huron.
Rowe, John A	Marysville.
Washtenaw County:	
Harmon, H. E	Willis.
Wayne County:	
Bicht, Wm. F	Redford.

GRAPHITE PRODUCERS, 1916.

Name.	Address.	Quarry.
[illegible] Graphite Co	[illegible] St., Detroit	L'Anse.
[illegible] Graphite Co	L'Anse	L'Anse.

GRINDSTONE AND SCYTHESTONE PRODUCERS, 1916.

Operator.	Office.	Quarry.
Huron County.		
Cleveland Stone Co	Cleveland, Ohio.	Grindstone City.
The Wallace Co	Port Austin	Eagle Mills.
Cleveland Stone Co	Cleveland, Ohio.	Port Austin.

PRODUCERS OF GYPSUM PRODUCTS, 1916.

Operator.	Office.	Name of plant.	Location of mine.
United States Gypsum Co	Chicago, Ill	Alabaster	Alabaster.
United States Gypsum Co	Chicago, Ill	Michigan	Grand Rapids.
Acme Cement Plaster Co	St. Louis, Mo	Mill No 5	Beverly.
Michigan Gypsum Co	Grand Rapids.		Grand Rapids.
American Cement Plaster Co	Lawrence, Kas	Grand Rapids	Grand Rapids.
Grand Rapids Plaster Co	427 Mich. Trust Bldg., Gd. Rapids.	Eagle Mill	Grand Rapids.
		Grandville	Grandville.

LIMESTONE AND LIME PRODUCERS, 1916.

Operators.	Office.	Quarry.
Alger County:		
The Munising Co.	11th Fl. Rockfeller Bldg., Cleveland. Ohio.	Eben.
Alpena County:		
Michigan Alkali Co.	Wyandotte	Wyandotte
Great Lakes Stone and Lime Co.	Alpena	Rockport.
Arenac County:		
McDonnell, Jas. (lime)	Twining	Omer.
Charlevoix County:		
Northern Lime Co. (lime)	Petoskey	Bay Shore.
Charlevoix Rock Products Co. (also lime)	Charlevoix	Charlevoix.
Cheboygan County:		
Campbell Stone Co. (also lime)	Indian River	Afton.
Cheboygan Limestone Prod'ts Co.	Mackinaw City	Mill Creek.
Chippewa County:		
Scott Quarry Co	Sault Ste. Marie	Trout Lake.
Delta County:		
Delta Contracting Co	Escanaba	Escanaba (Hyde).
Bichler Bros	Gladstone	Pine Ridge.
Bichler, John	Groos	Groos.
Berkman, Andrew J	Gladstone, R. F. D. No. 1	Gladstone, R. F. D. No. 1, Escanaba Twp.
Dickinson County:		
Metronite Co., The	Milwaukee, Wis	Felch.
Emmet County:		
Antrim Lime Co. (lime)	912 Mich. Trust Bldg., Grand Rapids	Petoskey.
Emmet Co. Rd. Comm'rs.	Brutus	
Northern Lime Co. (also lime)	Petoskey	Petoskey.
Petoskey Crushed Stone Co	Petoskey	Petoskey.
Huron County:		
Wallace Stone Co	Bayport	3 mi. E. of Bayport.
Jackson County:		
Lime Products Co	Jackson	Jackson.
Mackinac County:		
Ozark Stone Quarry	Ozark	Ozark.
Union Carbide Co	42nd St. Bldg., New York, N. Y.	Hendricks Quarry.
Fiborn Limestone Co	Sault Ste. Marie, Ontario, Can.	Fiborn Quarry.
Mackinac County Rd. Commrs.	St. Ignace	....
Marquette County:		
City of Negaunee	Negaunee	Negaunee.
Menominee County:		
Menominee Co. Road Commrs.	Menominee	....
Spencer, Henry	Menominee	Menominee.
Monroe County:		
Shore Line Stone Co	Monroe	Frenchtown.
The France Stone Co	1800 Second Nat'l Bank Bldg., Toledo, O	Monroe.
Morris, Sam W	Monroe	Monroe, S. part of City.
Presque Isle County:		
Michigan Limestone & Chemical Co	55 Liberty St., New York, or Rogers City, Mich	Calcite.
Schoolcraft County:		
The White Marble Lime Co. (Also lime).	Manistique	Blaney, Manistique and Marblehead.
Boylett, D. T	Crystal Falls	Blaney.
Fredun, Gust	Whitedale (Gulliver P. O.)	....
Delta Contracting Co	Escanaba	Manistique.
Wayne County:		
Solvay Process Co	Syracuse, N. Y	Trenton and Sibley.
Dunbar Stone Co	Detroit or River Rouge	Mouth of Detroit River.

MINERAL PAINT PRODUCERS, 1916.

Operator.	Pigment.	Office.	Location of plant.
Acme White Lead & Color Works	White lead, red lead, litharge, orange mineral	Detroit	Detroit.
Ditzler Color Co.		Detroit	Detroit.
Metronite Co.	Whiting (paint filler)	Milwaukee, Wis.	Dickinson Co.
Pickands, Mather & Co.	Met. Paint	Cleveland, Ohio.	Iron county.

MINERAL AND SPRING WATER PRODUCERS, 1916.

Operators.	Office.	Spring.
Arctic Spring Water Co.	412 Ottawa Ave., Grand Rapids	Arctic.
Bailey Marvel Springs Co.	Bellaire	Alden.
Willis, J. L.	Bangor	Beaver.
Bromo-Hygeia Mineral Water Co.	Coldwater	Bromo-Hygeia.
Crystal Spring Water, Fuel & Ice Co.	35 No. Division St., Grand Rapids	Crystal Spring.
Israelite—House of David	Benton Harbor	
Deep Springs Water Co.	Northville	
Eastman Springs Co.	Benton Harbor	Eastman.
Polaris Water Co.	Marquette	Lake Superior Mineral Spring.
Jarvis Mineral Water Co.	901 River Street, Lansing	Lansing.
Mt. Clemens Crystal Springs Water Co.	Mt. Clemens	Mt. Clemens Crystal Spring.
Ogemaw Spring Water Co.	Bay City	Ogemaw.
Dewitt, C. M.	Osseo	Osseo.
Ponce de Leon Co.	Grand Rapids	Ponce de Leon.
Pike, Lute H.	Topinabee	Sanitas.
Shorkey, Chas.	Mt. Clemens	Victory.
Ypsilanti Mineral Water & Bath Co.	Ypsilanti	Moorman Well.
Magnetic Spring Water Co.	Saginaw, W. S.	Andrew's Magnetic Mineral.
Beard Hill Mineral Spring Co.	105 E. Bancroft St., Toledo, Ohio	Avoca.
Charbeneau, Jno. H.	Mt. Clemens	Maple Leaf Springs.
Preussel, Frank W.	47 Crocker Ave., Mt. Clemens	Panacea.
Wall, R. I.	South Haven	Crystal.
Jackson, Roger	Crystal Falls	Sterling.
Sutton, Geo.	Hartford	Sultana.
Silver Springs Water Co.	Detroit	Northville.
McAlsfer Mfg. Co.	Mt. Clemens	Eureka.

PETROLEUM PRODUCERS, 1916.

Operators.	Address.
Michigan Central Oil & Mineral Co.	807 Pine St., Port Huron.
Stock Xylite & Oil Co., G. B.	Port Huron.

PIG IRON PRODUCERS, 1916.

Operator.	Office.	Name of furnace.	Location of furnace.
Lake Superior Iron & Chemical Co.	Detroit	Boyne City	Boyne City.
Lake Superior Iron & Chemical Co.	Detroit	Chocolay	Chocolay.
Mitchell-Diggins Iron Co.	Cadillac	Cadillac	Cadillac.
Detroit Furnace Co.	1069 Jefferson Ave., Detroit	Detroit	Detroit.
Detroit Iron & Steel Co.	149 Jefferson Ave., Detroit	A & B	Detroit.
East Jordan Furance Co.	East Jordan		East Jordan.
Cleveland Cliffs Iron Co.	Cleveland, Ohio.	Pioneer No. 1.	Gladstone.
Antrim Iron Co.	Antrim	Antrim	Antrim.
Pioneer Iron Co.	Marquette	Carp River	Near Marquette.
Pioneer Iron Co.	Marquette	Pioneer No. 2.	Near Marquette.
Stephenson Charcoal Iron Co.		Stephenson	Wells.
Charcoal Iron Co. of America	Detroit	Chocolay	Chocolay.
Charcoal Iron Co. of America	Detroit	Boyne City	Boyne City.
Charcoal Iron Co. of America	Detroit	Elk Rapids	Elk Rapids.
Charcoal Iron Co. of America	Detroit	Manistique	Manistique.
Charcoal Iron Co. of America	Detroit	Newberry	Newberry.
New Metals Process Co.	Marquette		Marquette.

POTTERY PRODUCERS, 1916.

Operator.	Office.	Works.
Ionia County:		
Ionia Pottery Co.	Ionia	Ionia.
Macomb County:		
Mt. Clemens Pottery Co.	Mt. Clemens	Mt. Clemens.
Oakland County:		
Pontiac Clay Pipe & Novelty Co.	Pontiac	Pontiac.
Wayne County:		
Jeffery-Dewitt Co.	Detroit	Detroit.
Hupprich, Anton	2161 Michigan Ave., Detroit	Detroit.
Pewabic Pottery & Tile Co.	2161 Jefferson St., Detroit	Detroit.
Hygeia Filter Co.	338 Denton Ave., Detroit	Detroit.

QUARTZ PRODUCERS, 1916.

Operator.	Office.	Mine.
Marquette County:		
Michigan Quartz Silica Co.	Milwaukee, Wis.	Ishpeming.
Marquette Trap Rock Co.	Marquette	Marquette.

SALT PRODUCERS, 1916.

Operators.	Office.	Works.
Bay County:		
Hine Lumber Co.	Sta. A., Bay City	W. Bay City.
Biglow-Cooper Co.	Bay City	Bay City.
Isabella County:		
Van Schaack & Sons, Peter	118 Lake St., Chicago, Ill.	Mt. Pleasant.
Manistee County:		
Filer & Sons, Vacuum Pan Salt Wks.	Filer City	Filer City.
The Buckley & Douglass Lumber Co.	381 River St., Manistee	Manistee.
Sands Salt & Lumber Co., Louis	Manistee	Manistee.
Mason County:		
Morton Salt Co.	Ludington	Ludington.
Stearns Salt & Lumber Co.	Ludington	Ludington.
Midland County:		
The Dow Chemical Co.	Midland	Midland.
Saginaw County:		
Mershon, Eddy, Parker & Co.	Saginaw	Carrolton.
Bliss & Van Auken Lumber Co.	Saginaw, W. S.	Saginaw.
Eastman Salt Products Co.	Saginaw, W. S.	Saginaw.
Estate of Edward Germain	Holland Ave. near Genesee St., Saginaw, E. S.	Saginaw.
Saginaw Plate Glass Co.	Saginaw, W. S.	Saginaw, W. S.
Saginaw Salt Co.	430 Shearer Bldg., Bay City	St. Charles.
Strable Lumber & Salt Co.	Saginaw	Saginaw.
St. Clair County:		
Michigan Salt Works	Marine City	Marine City.
Morton Salt Co.	717 Ry. Ex., Chicago, Ill.	Port Huron.
Diamond Crystal Salt Co.	St. Clair	Port Huron.
Marine City Salt Co.	Marine City	Marine City
Wayne County:		
Inland Delray Salt Co.	Detroit	Delray.
Solvay Process Co.	Detroit	Delray.
Detroit Rock Salt Co.	Scranton, Pa.	Detroit.
Mulkey Salt Co.	610 Equity Bldg., Detroit	Oakwood.
Kay Salt Co.	Charleston, W. Va.	Ecorse.
Worcester Salt Co.	168 Duane St., New York, N. Y.	Ecorse.
Michigan Alkali Co.	Wyandotte	Wyandotte.
Pennsylvania Salt Mfg. Co.	115 Chestnut St., Philadelphia, Pa.	Wyandotte.

SANDSTONE PRODUCERS. 1916.

Operator.	Office.	Quarry.
Houghton County:		
Portage Entry Redstone Co.	Jacobsville	Jacobsville.
Huron County:		
Cleveland Stone Co.	Cleveland, Ohio	Grindstone.
Wallace Co.	Port Austin	Grindstone City.

SAND AND GRAVEL PRODUCERS, 1916.

Operator.	Office.	Pit.
Alcona County:		
Jas. Bell & Co	Greenbush	Greenbush.
Huron Shore Gravel Co	Greenbush	Greenbush.
Allegan County:		
Sutler, Fred W	Byron Center	Burnips Corners.
Wiest, Peter	Dorr, R. F. D. 2	Dorr.
Terpstra, Geo	Dunningville, R. F. D. 1	Dunningville.
Kool, Henry	New Richmond	New Richmond.
Pierce, Myron	Otsego	Otsego.
Powell, J. C	Plainwell	Plainwell.
Craine, W. C	Douglass	Douglass.
Hilaski, Stanley	Hopkins, R. F. D. 3	Hilliards.
Fry, W. G	South Haven, R. F. D. 6	South Haven.
Purdy, P	Fennville	Saugatuck.
Gray, Tom C	Fennville, R. F. D. 2	....
Dendel, Martin	Allegan, R. F. D. 5	Monterey.
Stuby, J. F	Moline	Wayland.
Alpena County:		
Riley & Monkman	501 State St., Alpena	Alpena.
Antrim County:		
Sissons, F. E	Central Lake, R. F. D. 1	Central Lake.
McPherson, Guy	Eastport	Eastport.
Campbell, Wm. G	Mancelona	Mancelona.
Swan, Guy	Mancelona	Mancelona.
Burch, A. O	Central Lake	Central Lake.
Arenac County:		
Daniels, Wm	Sterling, R. F. D	Sterling.
Rogers, Sidney	Twining	Twining.
Mayor of Omer City	Omer	Omer.
Barry County:		
Woolston, Chas	Hastings	Hastings.
Hilt, Geo	Woodland	Woodland.
Renkes, Fred	Hastings	Hastings.
Dunham, P. O	Nashville	Grove Center.
Clever, Daniel	Nashville	Nashville.
Hinckley, C. G	Hastings	Hastings.
Bay County:		
Hayward, R	Bay City, R. F. D. 3	Bay City.
Histed, C. D	Munger	Munger.
Whitney, Geo. A	Bentley	Bentley.
Benzie County:		
Huddleston, Wm	Bendon, R. F. D. 1	Bendon.
Betsey River Orchards, Ben Newhall & Co	840 Ohio Bldg., Chicago, or Thompsonville, Mich.	Thompsonville.
Berrien County:		
Edgecombe, Geo. W	439 Main St., Benton Harbor	Benton Harbor.
Warren, Paul E	Lakeside	Lakeside.
Benton Harbor Sand Co	Benton Harbor	Benton Harbor.
American Sand & Gravel Co	Benton Harbor	Benton Harbor.
Garden City Sand Co	Riverside	Riverside.
Kerlikowske Bros	St. Joseph	St. Joseph.
Brewer, Frank	Galien	Galien.
Thar, Anton	Coloma, R. F. D. 3	Riverside.
Broderick Bros	Riverside	Riverside.
Brant, Mrs. Rebecca	Bridgeman	Bridgeman.
Swank, Wm	Galien	Galien.
Mettger, Henry	Berrien Springs	Oronoka.
Warren, E. H	Three Oaks	New Buffalo.
Branch County:		
Werner, Jake F	Bronson	Bronson.
Barnes, Mrs. J. M	Montgomery	Kinderhook.
Brehm, Jno. H	Kinderhook	Kinderhook.
Clark, Oliver	Kinderhook, R. F. D. 1	Kinderhook.
Wilkins, W. H	Coldwater, R. F. D. 3	Kinderhook.
Holcomb, Preston	Bronson	Bronson.
Graham, Herbert A	Elkhart, Ind	Union City.

SAND AND GRAVEL PRODUCERS, 1916.—*Continued.*

Operator.	Office.	Pit.
Calhoun County:		
Abbott, Wallace	315 Irwin Ave., Albion	
March, Andrew	Union City, R. F. D. 5	Union City.
Young, Willard A	Albion	Albion.
Blowers, N. A	Athens	Athens.
Funk, F. J	Battle Creek, R. F. D. 2	Battle Creek.
Hiscock, Seth	Battle Creek	Battle Creek.
Grosbeck, Fred	Burlington	Burlington.
Adrian, John	323 Hamblin Ave	Battle Creek.
Crystal Sand & Gravel Co	12 E. Main St	Battle Creek.
Cline, Eli	Battle Creek, R. F. D. 1	
Brownlee Park & Material Co	Battle Creek	Brownlee Park.
Michigan United Traction Co	Jackson	Marshall.
Prince, Wm. A	Ceresco	Ceresco.
Phillips, L. W	Burlington	Burlington.
Van Sickles, Elmer	Albion	Albion.
Cass County:		
La Grange Twp	Cassopolis	Cassopolis.
Crandall, Lester	Cassopolis	Cassopolis.
Blanchard, A. G	Niles	Niles.
Graham, H. A	Elkhart, Ind	Union.
Charlevoix County:		
Healy, Chas	East Jordan, R. F. D. 2	East Jordan.
Ward, E. B	Charlevoix	Charlevoix.
Cheboygan County:		
Charpointiar, Jos	Cheboygan, R. F. D. 2	Cheboygan.
Chippewa County:		
Belanger, Louis	Sault Ste. Marie	Sault Ste. Marie.
Rye, Jas	409 Maple St., Sault Ste. Marie	Sault Ste. Marie.
Taylor, F. H	Pickford	Pickford.
Clare County:		
Littlefield, J. L	Farwell	Farwell.
Clinton County:		
Parmenter, Geo	Shepardsville	Shepardsville.
Gleason, S. B	Ovid	Ovid.
Allen, Frank	Elsie	Elsie.
Keys, Hiram	St. Johns	St. Johns.
Wilhelm, Noah	Bath, R. D	Bath.
Mich. United Traction Co	Jackson	DeWitt.
Stowell, Elmer	Ovid	Ovid.
Coats, Lewey	Ovid	Ovid.
Delta County:		
Potvin, Louis	Garden	Garden.
Chicago & N. W. R. R	Chicago	Escanaba.
Escanaba Stone & Gravel Co	Escanaba	Escanaba, Flat Rock.
Jorgensen, Adolph	Escanaba	Escanaba.
Bereman, Andrew	Gladstone	Gladstone.
Romean, A	Bark River	Bark River.
Dickinson County:		
Chicago & N. W. R. R	Chicago	Iron Mountain and Loretto.
Vulcan Brick Works	Vulcan	Vulcan.
Miench, Anton	107 E. Fleisheim St., Iron Mountain	Iron Mountain.
Eaton County:		
Palmiter, S. J	Bellevue, R. F. D. 4	Bellevue.
Hull Bros	Dimondale	Dimondale.
Johnson, A. C	Eaton Rapids	Eaton Rapids.
LaRock, Hiram	Grand Ledge	Grand Ledge.
Gates, Burton	Grand Ledge	Grand Ledge.
Kent, V. M	Grand Ledge	Grand Ledge.
Saier, H. E	Lansing, R. F. D. 6	Millett.
Wells, C. E	Vermontville	Vermontville.

SAND AND GRAVEL PRODUCERS, 1916.—*Continued.*

Operator.	Office.	Pit.
Genesee County:		
Burns, Ed	Duffield	Duffield.
Farnham, Henry	Farnham, R. F. D. 3	Fenton.
Flint Sandstone Brick Co	Flint	Flint.
Reid, Alfred	Flint	Flint.
Scott, F. D	Genesee	Genesee.
Boston, H. W	Goodrich, R. F. D. 1	Goodrich.
Miner, Frank	Flint	Fenton.
Goodrich, Ford	Grand Blanc	
Stine, Martin	Goodrich	Goodrich.
Bowles, E	Linden	Linden.
Hogan, Daniel	Linden	Linden.
Brown, D	Duffield	Duffield.
Horning, A	Montrose	Montrose.
Johnson, Ernest	Swartz Creek	Swartz Creek.
Knox, Wm	Linden	Argentine.
Otisville Gravel Co	Saginaw	Otisville.
Goodrich, Wm. P	Goodrich	Goodrich.
Bigelow, Elma H	Grand Blanc	Grand Blanc.
Gladwin County:		
Wixom, F. L	Sanford	10 mi. S. of Beaverton.
Soldan, L. V	Butman	Butman.
Grand Traverse County:		
Koch, John	Mayfield	Mayfield.
Gratiot County:		
Church, I. H	Alma	Alma.
Dexter, Jas	Shepherd, R. D. 2	Summerton.
Sawvel, Robert	Breckenridge	Breckenridge.
Lippert, Jacob	Elwell	Elwell.
Curtis, C	Ithaca, R. F. D. 6	Ithaca.
Haas Bros	Northstar, R. F. D. 3	Northstar.
Tomlin, A	Sumner	Sumner.
Wiles, Wm	Sumner, R. F. D. 2	Sumner.
Church, E	Alma	Alma.
Hillsdale County:		
Zeiter, Geo	Reading	Camden.
Michigan Central R. R. Co	Jonesville	Jonesville.
Morgan, H. C	Camden, R. F. D. 37	Camden.
Scholfield, H. C	Pittsford	Pittsford.
Thompson, L. W	Waldron	Waldron.
Wolcott, C. Nelson E	Hillsdale	Hillsdale.
Kline, H. N	Camden	Camden.
Howald, Geo	Camden	Camden.
Houghton County:		
Winona Copper Co	Winona	Winona.
Huron County:		
Conkey, Sam	Caseville	Caseville.
Merrick Gravel Co	Pigeon	Pigeon.
Wallace Co., The	Port Austin	Port Austin.
Haskell, Miss Eliz. A	Port Austin	Port Austin.
Ingham County:		
Artz, Joe	Leslie	Sec. 23, Bunker Hill Twp.
Atkinson, Mr	Mason	S. W. Cor. Sec. 16, Vevay Twp.
Bell, O. E	Mason or Lansing	Sec. 36, Delhi Twp.
Bunker, Chas	Leslie or Stockbridge	Sec. 35, Bunker Hill Twp.
Burwell Sand & Gravel Co	S. Wash. Ave., Lansing	Lansing.
Corwin, W. L	Williamston	Sec. 2, Wheatfield Twp.
Couch, Chas	Mason	Sec. 25, Aurelius Twp.
Curtiss, Bert	Williamston	N. E. Cor. Sec. 21, Wheatfield Twp.
Potts, W. S	Mason, R. F. D. 1	Mason.
Dubois, D. D	Leslie	Sec. 28, Bunker Hill Twp.
Frost, A. J	Williamston	Sec. 22, Wheatfield Twp.
Frost, J. F	Williamston	Sec. 26, Wheatfield Twp.
Holbrook & Skinner	Lansing	Lansing (Holt).
Linn, Lew	Williamston	Sec. 15, Wheatfield Twp.
Saier, H. E	Lansing, R. F. D. 6	Lansing.
Stockman, F. M	Lansing	Lansing.
Campbell, Hugh	1516 6th St., Bay City	Mason.

SAND AND GRAVEL PRODUCERS, 1916.—*Continued.*

Operator.	Office.	Pit.
Ingham County:—Con.		
Nice, Geo	Mason	Sec. 6, Vevay Twp.
Okobock, Dennis	Mason	Sec. 5, Vevay Twp.
Potts, Walter F	Mason, R. F. D. 1	Mason.
Rappe, A	Lansing or E. Lansing	Sec. 16, Meridan Twp.
Porter	Williamston	Sec. 34, Williamston Twp.
Sheltraw, A. E	Saginaw	Mason.
Smith, Geo	Mason	Sec. 10, Vevay Twp.
Stevens, F. B	Mason	Sec. 5, Vevay Twp.
Victory, Ward	Leslie or Stockbridge	Sec. 36, Bunker Hill Twp.
Michigan United Traction Co.	Jackson	Sec. 25, Delhi Twp., Mason and Haslett.
Warner, Mr	Mason	N. W. Cor. Sec. 36, Aurelius Twp.
Williams, C. W	Williamston	Sec. 35, Williamston Twp.
Winters, J. P	Leslie or Stockbridge	Sec. 25, Bunker Hill Twp.
Hunter, DeWitt	Lansing	Lansing.
Ionia County:		
Crawford, Geo. W	Ionia, R. F. D. 3	Ionia.
Glick, Cephas M	Lowell, R. F. D	Saranac.
Ionia Cement Products Co	Ionia	Ionia.
Miller, Henry	East Main St., Ionia	Ionia.
Normington, Frank	Ionia, R. F. D. 1	Ionia.
Knapp, A. M	Ionia, R. F. D. 7	Ionia.
Trowbridge, Forest P	Ionia	Ionia.
Elvert, E. J	Muir, R. F. D	Muir.
Hazelitt, J. I	Ionia, Star Route	Palo.
Dansinger, Samuel	Saranac, R. F. D. 1	Saranac.
Gilmore, Niel	Shiloh	Shiloh.
Fellows, Jas. M	Lake Odessa	Lake Odessa.
Hauserman, Herman	Lake Odessa, R. F. D	Lake Odessa.
Millard, Seymour	Palo	Palo.
Ronald Twp. Gravel Pit	Palo	Palo.
Grieves, Mrs	Saranac, R. F. D. 12	Saranac.
Keyser, Chas	Saranac, R. F. D. 10	Saranac.
Dusman, Sam	Saranac	Saranac.
Iosco County:		
Boomer & Son, Jno	Tawas City	Tawas City.
Iron County:		
Ross, D. M	Crystal Falls	Crystal Falls.
Chicago, Milwaukee & St. Paul R. R	Chicago	Crystal Falls.
Isabella County:		
Coughlin, Will	Shepherd, R. F. D. 1	Shepherd.
Dexter, James	Shepherd	Shepherd.
Merrill, D. R	Shepherd, R. F. D. 5, Box 15	Shepherd.
Jackson County:		
Greenville Gravel Co	Greenville, O	Ackerman Lake, 3 mi., S. of Jackson.
Cooper, Fred B	Horton	Horton.
Winters, J. P	Jackson	Jackson.
Kimball, D. G	Jackson	Napoleon.
Blake, Wm	Jackson, R. F. D. 6	Jackson.
Emmons, Wm. P	123 Clinton St , Jackson	Jackson.
Watts, C. R	Jackson, R. F. D. 2	Jackson.
Berm, C. E	Parma	Parma.
Mich. Central R. R. Co	Detroit	Bloomerville.
Mich. United Traction Co	Jackson	Michigan City.
Hunn, G. L	Parma	Parma.
Kalamazoo County:		
Mich. United Traction Co	Jackson	Augusta.
Miller, J. B	Augusta	Augusta.
Balch, Wm. A	Kalamazoo	Kalamazoo.
Buurma, Sam'l H	Kalamazoo	Kalamazoo.
Haas Bros	Kalamazoo	Kalamazoo.
Huff, Archie	Kalamazoo	Kalamazoo.
Kalamazoo Gravel & Sand Co.	Kalamazoo	3 or 4 mi. N. of Kalamazoo on G. R. & I. siding.
Klepper, Jacob	Kalamazoo	Kalamazoo.
Molhock, Peter	Kalamazoo	Kalamazoo.

SAND AND GRAVEL PRODUCERS, 1916.—*Continued.*

Operator.	Office.	Pit.
Kalamazoo County.—Con.		
Owens, Michael	Kalamazoo	Kalamazoo.
Russell, Jas. T	Kalamazoo	Kalamazoo.
So. Mich. Brick Co	Kalamazoo	Richland Twp.
Mich. United Traction Co	Jackson	Augusta.
Gunn, J. W	Watervliet	Williams.
Kalamazoo County Rd. Comm.	Kalamazoo	Kalamazoo.
Kalkaska County:		
Anderson, Lynn	Kalkaska	Kalkaska.
Hayward, W. F	South Boardman	South Boardman.
Kent County:		
Holt, C. E	Ada, R. F. D. 42	Ada.
Deiss, Jos	Ada, R. F. D. 17	Alpine.
Read, Percy	Alpine	Alpine.
Brewer, Earl	Byron Center, R. F. D	Byron Center.
Battjes Fuel & Bldg. Mat. Co	Grand Rapids	Grand Rapids.
Bunker Co., G. W	Grand Rapids	Grand Rapids.
Harrison Land Co., Ltd	Grand Rapids	Grand Rapids.
Carpenter Construction Co	Grand Rapids	Grand Rapids.
Pinyon, S. G	Grand Rapids	Grand Rapids.
Valley City Stone & Gravel Co.	Grand Rapids	Grand Rapids.
Ide, D. K	Grandville	Grandville.
Maloney, Pat	Harvard, R. F. D. 40	Harvard.
Holmgren, E. A	Kent City	Kent City.
Kriger, M	Kent City	Kent City.
Ryno, M. J	Ross, R. F. D	Ross.
Farnam, Reuben	Sand Lake	Sand Lake.
Standard Builders Supply Co	Grand Rapids	Grand Rapids.
Sargeant, John	Lowell	Lowell.
Trumm, C. C	Kent City	Tyrone Twp.
Mich. Railway Co	Jackson	Grand Rapids.
Lake County:		
Saunders & Co., G. W	Chase	Chase.
Lapeer County:		
Hallock, Roy P	Almont	Almont.
Miteen, Fred	Goodrich	Goodrich.
Caley, M	Metamora	Hunters Creek.
Broecher, Augut W	Goodrich, R. F. D. 2	Hadley.
Spears, W. A	Columbiaville, R. F. D. 3.	3 mi. S. E. of Columbiaville.
Leelanau County:		
Bronson, Margaret	Maple City, R. F. D. 1	Maple City.
Lenawee County:		
Shannon, F. J	Adrian	Adrian.
Smith, Porter C	Clinton	Clinton.
Fuller, Charles	Hudson	Hudson.
Lockwood, Sam	Hudson	Hudson.
Lowe, Frank	Hudson	Hudson.
Evans, Geo	N. Morenci	N. Morenci.
Gillispie, R. P	Tecumseh	Tecumseh.
Wilson, Ira	Tecumseh, R. F. D. 3	Tecumseh.
Tecumseh Gravel Co	Tecumseh	Tecumseh.
Baldwin, V. E	Morenci	Morenci.
Livingston County:		
Ohio & Michigan Sand & Gravel Co	1025 Nicholas Bldg., Toldo, Ohio	Chilson.
Coles, Ben	Fowlerville	Fowlerville.
Arnold, O. B	Gregory	Gregory.
Butler, Dwight	Hamburg	Hamburg.
Hosby, E. B	Howell	Howell.
Thomas, Henry	Oak Grove	Oak Grove.
Macomb County:		
Blay Bros	Mt. Clemens	Clinton River.
Horning Gravel Co	412 Weadock Bldg., Saginaw	Armada.
Pratt, Ben J	Armada	Armada.
Chapman, Jas	Memphis	Memphis.
Lake Side Ice & Coal Co	Mt. Clemens	Mt. Clemens.
Harder, Henry	Richmond	Richmond.

SAND AND GRAVEL PRODUCERS, 1916.—*Continued.*

Operator.	Office.	Pit.
Macomb County:—Con.		
Wacker, H. Jacob	Mt. Clemens	Mt. Clemens.
Clark, Chas	Utica, R. F. D. 2	Utica.
Detroit Sand & Gravel Co	34 McGraw Bldg., Detroit	Utica.
Superior Sand & Gravel Co	Detroit	Utica.
Ruff, Michael	Lennox, R. F. D	Richmond.
Manistee County:		
Hubbell Sand Co	Manistee	Manistee.
Summerfield, Porter M	Manistee	Manistee.
Farr, M. A	Onekama	Onekama.
McMartin, Chas	Chief, R. F. D. 2	Chief.
Johnson, John	Chief	Chief.
Marquette County:		
Chicago & N. W. R. R	Chicago	Michigamme.
Champion Sand & Gravel Co	Marquette	Champion.
Mason County:		
Hall, Ed	Custer, R. F. D. 2	Custer.
Szymanski, Geo	Freesoil, R. F. D. 2	Freesoil.
Wahr, John	Freesoil, R. F. D. 2	Freesoil.
Beaune, Oliver	Ludington, Box 68	Ludington.
Clark, Henry	Ludington	Ludington.
Lorentz, Ferdinand	Ludington	Ludington.
Dodge, C. C	Tallman	Tallman.
Edmonson, James	Tallman	Tallman.
Percy, Stanton	Ludington	Ludington.
Hubbell Sand Co	Manistee	Ludington.
Mecosta County:		
Conklin, Wm	Big Rapids, R. F. D. 5	Big Rapids.
Riley, J. E	Millbrook, R. F. D. 2	Millbrook.
Carmichael, Ed	Evart	Chippewa Twp.
Main, W. J	Millbrook	Millbrook.
Stone, C. E	Hersey	Hersey.
Menominee County:		
Capt. Nels Olsen	Menominee	Menominee.
Schoen, Jno. W	Wilson	Wilson.
Midland County:		
Crane, H. A	Midland	Hope.
Gehoski, Mike	Midland, R. F. D. 1	Midland.
Schukofski, G. T	Midland, R. F. D. 1	Near Midland.
Missaukee County:		
Pickering, O. L	Lake City	Lake City.
Reeves, Kary D	McLean, Ill	McBain.
Monroe County:		
Falmstock, Emerson	Carlton	Carlton.
National Silica Co	Steiner	Steiner.
Montcalm County:		
Belknap Cement Products Co	Greenville	Greenville.
Boezwinkle, Wm	Pierson	Pierson.
Matz, Chas	Pierson	Pierson.
Tissue, Leonard	Stanton, R. F. D. 1	Stanton.
Sinkley, Mrs. L. M	Carson City	Carson City.
Anderson, Holgen	Greenville, R. F. D. 3	Greenville.
Williams, E. O	Edmore	Edmore.
Muskegon County:		
Bettis, Phil	Ravenna, R. F. D	Ravenna.
Homer, Wm	Ravenna, R. F. D	Ravenna.
Valley, Edw	Twin Lakes	Twin Lakes.
Barlow, John C	Muskegon	Casnovia.
Newaygo County:		
Wentland, Mrs. Johanna	Woodville	Woodville.
Hall, A. E	Newaygo	Newaygo.
Raymond, R. J	Grant	Grant.

SAND AND GRAVEL PRODUCERS, 1916.—*Continued.*

Operator.	Office.	Pit.
Oakland County:		
Park & Son, A. H	Birmingham, R. F. D. 2	Birmingham.
Mich. Portland Cement Paving Co	Griswold St., Detroit	Clarkston.
Ely, C	Farmington	Farmington.
Rice, E. J	New Hudson	New Hudson.
Campbell, John	Ortonville, R. F. D. 2	Ortonville.
Detroit-Oxford Gravel & Stone Co	Oxford	Oxford.
Bartlett, C. S. & A. S	Pontiac	Pontiac, 2 miles E.
Kemp, W. H	Pontiac	Pontiac.
Rockwell, C. L	Pontiac	Pontiac.
Slater Construction Co	Pontiac	Pontiac.
Heal, Geo	669 Baker St., Detroit	Rochester.
Rochester Sand & Brick Co	Detroit	Rochester.
Boomer Sand & Gravel Co	520 Forest St. E., Detroit	Rochester.
Thompson, W. R	100 Beaubien St., Detroit	Goodison.
Adams & Cummings	1105 Kresge Bldg., Detroit	New Hudson.
Oceana County:		
Aldrich, A. O	Hart	Crystal Valley.
Golden Twp. Pit	Mears	Mears.
Twp. Board of Newfield	Hesperia	Hesperia.
Cartright, Thos	Rothbury, R. F. D. 1	Rothbury.
Wherle, Frank	Rothbury, R. F. D. 1	Rothbury.
Ogemaw County:		
Brooks, H. F	Rose City	Rose City.
Harvey, D	West Branch, R. F. D. 1	West Branch.
Osceola County:		
Carmichael, Ed	Evart, R. F. D. 1	Evart.
Stone, Chas. E	Hersey, R. F. D. 1	Hersey.
Hoogerhide, Jno	Reed City, R. F. D. 6	Reed City.
Marvin, Seymour	Tustin, R. F. D. 1	Tustin.
Marquette Gravel Co	Saginaw	Evart, 4 mi. W. of.
Hale, C. H	Hersey	Hersey.
Ottawa County:		
Holtrop, Jno	Ferrysburg	Ferrysburg.
Graham, Mrs. T	West Olive	Grand Haven.
Walsma Van Toll Co	Grand Haven	Bass River.
Van Weelden & Co., J	609 Fulton St., Grand Haven	Grand Haven.
Presque Isle County:		
Kroll, Andrew	Posen	Posen.
Roscommon County:		
Campbell Gravel Co	Roscommon	Roscommon.
Saginaw County:		
Moilest & Donely	336 Howard St	Saginaw River.
St. Clair County:		
Armitage, Sidney	Atkins, R. F. D. 1	Atkins.
Kinney, Chester	Atkins, R. F. D. 1	Atkins.
Snyder, Wm	Atkins, R. F. D. 1	Atkins.
Kitchen, Cyrenius	Smiths Creek	Goodells.
McGennett, Jas	Smiths Creek	Smiths Creek.
Westrick & Son, C. A	Marine City	Marine City.
Caldwell Transit Co	1805 Dime Bk. Bldg., Detroit	St. Clair River and Lake.
United Fuel & Supply Co	Foot of 1st St., Detroit	Algonac.
Marine Contracting Co	211 Quay St., Port Huron	Port Huron.
James Co., R. C	Port Huron	Port Huron.
Superior Sand & Gravel Co	726 Dime Bank Bldg., Detroit	Marine City.
Thompson Co., W. R	Detroit	Port Huron.
St. Joseph County:		
Hill, S	Colon	Colon.
Kerlikowske Bros	St. Joseph	St. Joseph.

SAND AND GRAVEL PRODUCERS, 1916.—*Concluded.*

Operator.	Office.	Pit.
Sanilac County:		
Buck, C. J.	Marlette	Marlette.
Gilbert, Geo	Melvin, R. F. D. 6	Melvin.
Mills, Henry	Minden City	Minden City.
Dawson & Son	Sandusky	Sandusky.
Carney, Chas	Sandusky	Sandusky.
Shiawassee County:		
Graham, John	Byron	Byron.
Shannon, A. E	Byron	Byron.
Schultz, A. A	Laingsburg	Laingsburg.
Hibbard, Joseph	Byron	Byron.
Barnes, O. L	Byron, R. F. D. 1	5 mi. from Byron.
Tuscola County:		
Hile, Tom	Caro, R. F. D. 2	Caro, S. W. of Caro in Juanita Twp.
Baker, Gilbert	Kingston	Kingston.
Whittaker, Benson	Kingston	Kingston.
Hill, Elmer A	Unionville	Silverwood.
Van Buren County:		
Bennett & Son, Warren	Hartford	Hartford.
Burger, F. A	Bangor	Bangor.
Hoppin, A. D	Bangor	Bangor.
Shine, John	Bangor	Bangor.
Sherburn, John	Decatur	Decatur.
Otis, L. L	Kibbie	Kibbie.
Wright, J. E	Lawrence	Lawrence.
Fry, W. G	South Haven	South Haven.
Funk, Merrifield	South Haven	Lakeside.
Washtenaw County:		
City Concrete & Coal Co	1015 Dime Bank Bldg., Detroit	Delhi.
Eddie, Geo	Ann Arbor, R. F. D. 8	Ann Arbor.
Fiegel, Fred	Ann Arbor, R. F. D. 3	Ann Arbor.
Pease, Wm	Saline, R. F. D	Saline.
Youngs, Ed	Saline, R. F. D	Saline.
Crane, Mortimer R	217 Mich. St., Ypsilanti	Ypsilanti.
Elsifor, S. A	117 First St., Ann Arbor	Ann Arbor.
Washed Clean Sand & Gravel Co	Ann Arbor	Dexter.
Cadillac Sand & Gravel Co	1452 Penobscot Bldg., Detroit	Ann Arbor.
Wayne County:		
Detroit United Fuel & Supply Co	Detroit, Free Press Bldg	Utica and Detroit.
Wabash R. R. Co., American Silica Co	Rockwood	Rockwood.
Thompson, W. R	Detroit, 606 Kress Bldg	Detroit.
Pryor, R. C	Detroit, 933 Dime Bank Bldg	1½ miles E. of Rockwood.
Wexford County:		
Selma Twp. Pit	Cadillac	Boon.
Fewless, John	Manton, R. F. D. 3	Manton.

TRAP ROCK PRODUCERS, 1916.

Operator.	Office.	Quarry.
Marquette County:		
Durocher, T. L	Marquette	Marquette.
The Park Cemetery Stone Co	Marquette	Marquette.
City of Negaunee	Negaunee	Negaunee.
Marquette Trap Rock Co	Marquette	Marquette.
Houghton County:		
Winona Copper Co	Winona	Winona.

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